BIENNIAL REPORT

OF THE

INSPECTOR OF COAL MINES

OF THE

STATE OF MONTANA

FOR THE YEARS

1905-6

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JOSEPH B. McDERMOTT,
Inspector

December 1st, 1906

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LETTER OF TRANSMITTAL.

Office of the Inspector of Coal Mines:

Helena, Montana, December 1, 1906.

Sir—I have the honor to submit herewith my biennial report of this department for the years 1905-6, complying with Section 5, Senate Bill 106, Laws of 1901, the Act creating the office of Inspector of Coal Mines for the State of Montana.

Respectfully,

JOSEPH B. McDERMOTT,
State Coal Mine Inspector.

His Excellency, Joseph K. Toole,
Governor of Montana.

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Showing
COAL AND LIGNITE AREAS

Legend
Bituminous
Lignite
Mines

Based on U. S. Geological Survey Maps
and Personal Field Work.
J P ROWE.
1905.

SCALE — 0 — MILES

FLATHEAD
TETON
CHOUTEAU
VALLEY
GLACIER
PONDERA
MISSOULA
POWELL
LEWIS & CLARK
CASCADE
FERGUS
DAWSON
GRANITE
DEER LODGE
JEFFERSON
BROADWATER
MEAGHER
RAVALLI
SILVER BOW
GALLATIN
PARK
SWEET GRASS
YELLOW STONE
CARBON
CUSTER
BEAVER HEAD
MADISON

Kalispell
Cheteau
Fort Benton
Great Falls
Glasgow
Culbertson
Missoula
Helena
Philipsburg
Deer Lodge
Hamilton
Boulder
Townsend
Butte
Anaconda
Big Timber
Livingston
Bozeman
Billings
Virginia City
Red Lodge
Miles City
Glendive
White Sulphur Springs
Thompson Falls
Darby
Dillon

INTRODUCTORY.

In the production of this report the department has endeavored to confine itself strictly to the limits of its official sphere—the coal industry. And in doing so, a presentation of the coal field, with its subdivisions, its classification of their coals and their quality and comparative efficiency, is given with a view to calling the attention of the outside world to this great natural resource of the state, and to the possibilities it affords for the profitable investment of capital at this time.

Though the coal output of the state shows a rather satisfactory and steady increase, foreign coal to the estimated amount of over a million tons was imported during the present year, these importations being largely from Lethbridge, the coal being brought to Great Falls over the Great Falls & Canada railway, and thence distributed to Helena, Butte, Anaconda and other points, by the Montana Central railway; Wyoming coal brought in by the Oregon Short Line railway and distributed to Butte, Anaconda, Helena and points west; and large importations by the Burlington railway that are distributed each way from Billings; and at the same time there has been an irritating shortage in the supply that at times has almost amounted to a "coal famine" in the domestic market.

It is therefore apparent, that the present home market affords the most attractive inducement for capital to develop some parts of our great coal areas and set them to producing at least, the fuel required to supply the daily home consumption. But the coal producers of the state should not be satisfied or limited to supplying this home demand. The industry should be so developed as to extend its market east to St. Paul and west to the boundary meeting of competition with Washington coals. The nature of the coal measures and the quality of the coals, allow such economy of working and provide such satisfactory steam and domestic fuel, that the seizure of extensive outside markets is simply a question of providing the necessary tonnage and invading the field.

The electrical wizard, Thomas A. Edison, predicts that within the next few years the secret of the production of electricity

by direct process will be discovered, and that then, instead of coal mining centers producing the coal and shipping it at great expense to surrounding industrial points where its efficiency is employed in developing power and heat, the coal mining centers will become the sites of great electrical generating plants, and that from them the power, light and heat will be conducted over wires to every desired point of the field of patronage. Speaking of the probabilities and possibilities in this line, Mr. Edison says: The first great change in the production of electricity will abolish carrying coal for that purpose. Instead of digging gross material out of the earth, loading it on cars and carrying it, say 500 miles, there to put it under a boiler and burn, and so get power, we shall set up plants at the mouths of mines, generate power there, and transmit it to wherever power is nedeed, by copper wire. It is preposterous to keep on putting coal mines on wheels. It is too clumsy. It is easier to carry molecular vibration by millions of waves a second, than freight cars full of crude matter. We can ship 100-thousand horse power over the wire quicker and more economically than we can send the equivalent in coal over a railroad track. We must eliminate the railroad altogether from this problem. What is the use of it? We do not want coal, anyhow. It does us no good to look at it. What we want is the resultant of the utmost energy that it can produce. And there is no sense in carrying around millions of tons of raw material like coal when we can get the product delivered to you by wire. Everything points to the fact that in the near future electricity will be produced for general consumption by great power houses at the mouths of coal mines. That is the logical and common sense outcome of present events. Now, the truth is, that it will cost very much less to transport electrical power by wire than to carry it in the form of coal on the railways. The great extension in the use of electricity which would follow this discovery, would also certainly to an increased demand for copper, a demand which it is claimed today is greater than the supply.

The practical application of this theory is, perhaps, nearer than the most optimistic anticipate. "Necessity is the mother of invention," is an old saying, and at this time the conditions caused by the scarcity of coal in the markets, when at the same time there are many mines operating and many others that could be made large producers in a short time, and the inadequacy of

the railway service, certainly make the incentive for live and wide a-wake men with capital to initiate the ideal theory. ne of the greatest of living railroad men is credited with saying that none regret more than the railroad men themselves, the inability of the railroads to cope with the present situation. It is reported that citizens of North Dakota wired their governor asking him to consult with Governor Johnson of Minnesota, as to the advisability of using the militia of both states to force the railways to transport coal. Surely the idea of saving the transportation of coal could not meet with very much opposition from the railroads, and whether it did or not, their opposition would not be material. It is a deplorable state of affairs to face the possibility of freezing to death, when Almighty God provided the state so bountifully with good coal.

Two theories for the source of coal are advanced by eminent geologists—the coal was formed on the spot where the forest grew; the coal was the result of accumulated drift. But all agree that it is the result of the decomposition of vegetable matter, and the theory most generally accepted is the former, or a combination of both, and it has been demonstrated in some instances, that areas of coal have been formed by organic matter drifted into lakes. Le Conte says. "Plants take the greater portion of their food from the air, and give it, by the annual fall of leaf and finally by their own death, to the soil." Thus, each generation takes from the air and adds to the soil continuously and without limit." Dana says: "There is no reason to suppose that the vegetation was confined to the lower lands; it probably spread all over the continent of America, to the most northern limits. It formed coal only where there were marshes, and where the deposits of vegetable debris afterwards became covered by deposits of sand, clay or other rock material. The theory that coal has been accumulated by the growth of vegetation in situ, as in peat swamps of the present date, is supported by the purity of the coal in some of the coal fields of this continent, the ash not being greater than would result from the plants of which it is composed."

However eminent geologists may differ on the subject, and support their theories and opinions, with those who are familiar with the distribution of coal beds throughout Montana, their sentiment will lead them to regret that, whether the deposits

are from vegitation in place or from drift or both, Silver Bow, Jeffeson and Sanders, out of all the counties of the state, were not favored by nature with coal measures of commercial value.

The immensity of the world's coal business can scarcely be appreciated even when it is stated that the production last year reached the enormous amount of 1,033,125,971 tons. Of this great mountain of coal, the United States produced thirty-eight per cent, and its aggregate output was nearly fifty per cent greater than that of Great Britain, and incomparably greater than that of any other country.

The gross production of coal in the United States, since the earliest mining record, is 5,970,773,571 tons, not including the production for this year, which will run well over 400,000,000 tons. The total coal output of the United States last year was 392,914,341 tons.

The Rocky mountain region embraces the largest coal field of the continent, in area, it now being credited with 100,000 square miles, and this estimate will unquestionably be greatly added to by the prospecting of uncredited lands during the next few years.

Montana is credited with having within her borders 32,000 square miles of coal lands, and it is acknowledged that there are considerable known areas of coal lands that are not embraced in this estimate.

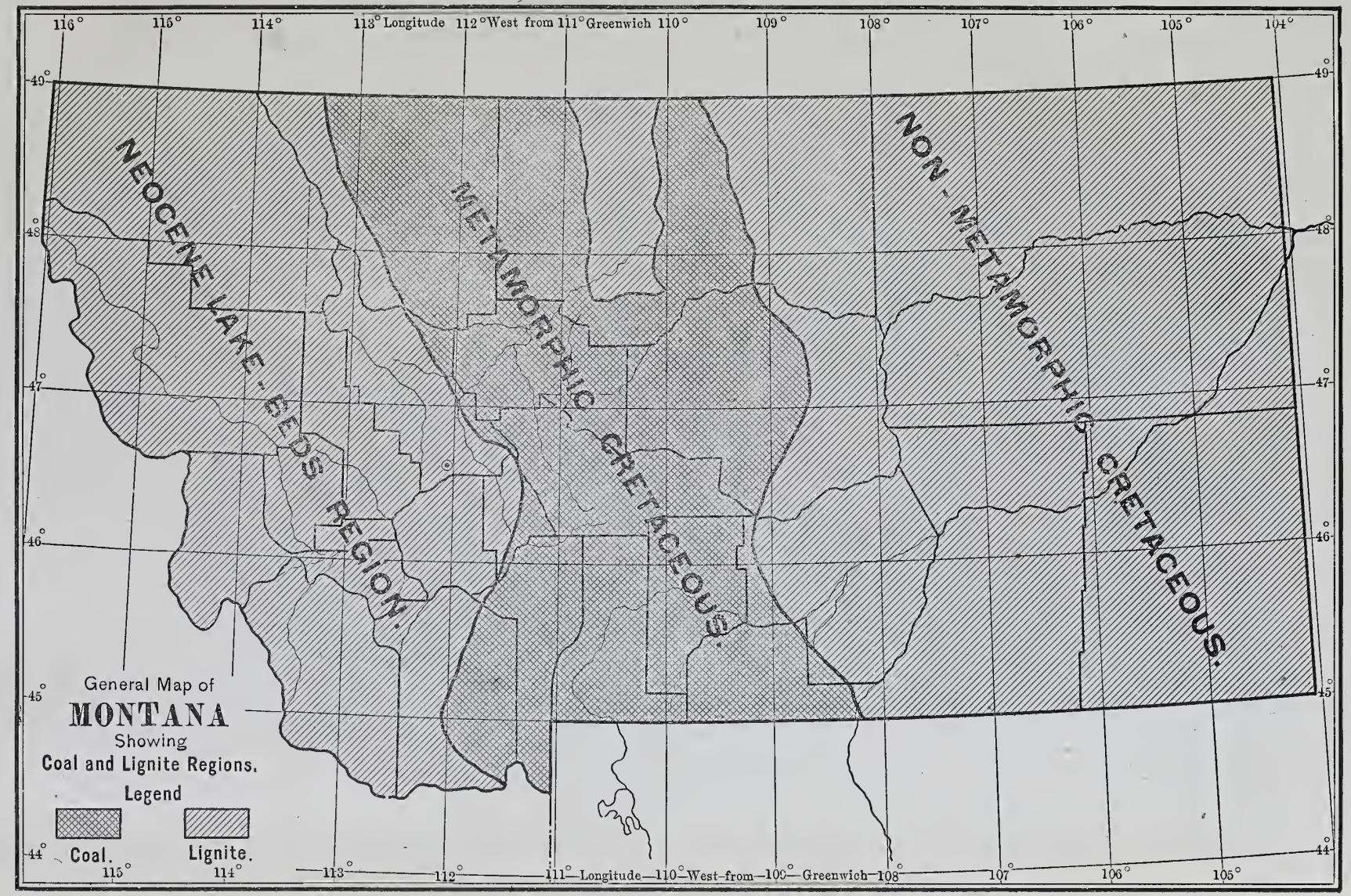
In 1904 Montana ranked twenty-first among the coal producing states, and the value of its coal product ranked twentieth; in 1905 it ranked twentieth in the amount of production and nineteenth in its value.

In classifying the coal production of Montana for last year, the coal department of the Interior department credits the bituminous with a little more than half the amount of the semi-bituminous output, with a small amount of lignite, a few tons of canal coal and a thousand tons of semi-anthracite.

The coal production of Montana for the past twenty-six years has been as follows: 1880, 224 tons; 1885, 86,440 tons; 1890, 517,477 tons; 1895, 1,504,193 tons; 1900, 1,661,775 tons; 1905, 1,743,771 tons; for the ten months of 1906, 1,502,200 tons. The figures for and prior to 1900 are those of the general government department, and for 1905-6 those collected by this department.

About one-half of the coal tonnage of the state is now pro-

PLATE I.


116° 115° 114° 113° Longitude 112° West from 111° Greenwich 110° 109° 108° 107° 106° 105° 104°
49° 48° 47° 46° 45° 44°
NEOCENE LAKE BEDS REGION.
METAMORPHIC CRETACEOUS.
NON-METAMORPHIC CRETACEOUS.
General Map of
MONTANA
Showing
Coal and Lignite Regions.
Legend
Coal.
Lignite.
115° 114° 113° 112° 111° Longitude 110° West from 109° Greenwich 108° 107° 106° 105°

duced by machines, and the average per man for the year was something over 542 tons.

The small increase in the tonnage of the past few years, makes it appear to the casual reader that there has been little growth in this line of the state's resources; but the fact is, that there has been more opening of new properties and development of small properties during the past two years than for many previous years, and there is promise that the next couple of years will witness many of these become large and regular producers. A couple of years ago there were but twenty-five or thirty properties reporting, while this year there are reports on file in this department from forty greater or lesser producers. Some of the large producers have considerably reduced their output during the past couple of years, and this reduction has been made up by the new and for the present, small producers. The increase of coal consumption, which has been large, has been provided by importations from Canada and Wyoming which have been successfully meeting the competition of our better grades of coal in especially the domestic market owing to the persistent shortage of the home supply. The indications are, however, that there will be a large increase of output next year by the larger mines, and with the growth of the smaller concerns and the mines that will be opened along the lines of the Chicago, Milwaukee and St. Paul, and Burlington railways, which are building across the state, and which traverse extensive coal fields, will greatly increase the coal output of the state and place it still nearer the head of the coal producing states. With the rapid development of the illimitable resources of this state and the settlement and improvement of its great stretches of fertile bench and valley lands that is taking place, with the great coal fields to be opened and made to produce the fuel for the industries and the homes that are being established, the coal industry of the Treasure State will soon rank far ahead of that of any other of the mountain states; and with an abundant margin at present offered by the home market, there is ample encouragement for the increase of the output of the established mines and for the development of many new producers; capital entering this line of most profitable investment can feel fully assured of ample and certain returns.

Coal-bearing formations in Montana are found in all the rocks from the Jurassic to the Tertiary, but most of the coal is of

the Cretaceous age. The coal found in the Jurasic is thin and in most cases can not be profitably worked. The coals of the state vary in their character from lignite to bituminous, some of the latter being coking coals. The chief producing areas are at present in Cascade, Carbon and Park counties, though coal is being mined to a considerable extent in Fergus, Valley, Meagher, Gallatin, Granite, Deer Lodge, Custer and Chouteau counties, and all of these counties will during the next couple of years become large producers and will have Flathead, Powell, Teton, Sweet Grass and Dawson added to the list. Jesse P. Rowe, Ph. D., in a paper on the coal-bearing formations of the state, says the coal and lignite are found principally in the Kootenai, Laramie and Fort Union of the Cretaceous. Many undeveloped seams of lignite are found in the Neocene of the western part of the state; the Laramie, however, being the chief coal-bearing formations of the Rocky mountains, reaching its highest development in Montana, where it covers nearly twot-hirds of the state. The eastern half of the state is literally underlain with seams of Laramie lignite of varying thickness and often of exceptional purity. The principal seams of Laramie are found at the base of the mountains and Kootenai bituminous coals of excellent quality, varying from the dry steam coals to good coking varieties. Part of these bituminous seams are older than the plains lignite and part of them are younger. The coal seams at Sand Coulee, Stockett, Belt, Lewistown and Toston, have been determined by Prof. Newberry as Kootenai or lower Cretaceous; and those at Cokedale, Chestnut, Stoors, Aldridge, Bear Creek and Mountainside as Laramie, and at Red Lodge as Fort Union. There are many fine beds of Neocene lignite in the valleys of the western part of the state. Coal that can be classified as anthracite has been found in but three places in the state. The eastern portion of the state is a continuation of the trans-Mississippi plains. The western part is a complex of mountain ranges where the folding and faulting reached high development. The eastern part of the state belongs to the Great Interior Area of the Cretaceous. The mountainous portions of the state exhibit strata from the Archaen up, and the Silurian, Devonian and Carboniferous are well shown in many localities, as well as are the Triassic and Jurassic. The Neocene lake beds are scattered chiefly over that portion of the state lying west of the Rockies, and especially in Flathead, Powell, Granite, Beaverhead, Missoula and

Ravalli counties, and the Smith river valley, lying principally in Meagher county, and east of the range.

LOCATION OF GEOLOGICAL FORMATIONS.

Following is given the location of geological formations in Montana, with some of their characteristic fossils, the tables being the work of Prof. Jesse P. Rowe, Ph. D.:

PERIODS.		LOCALITIES.	CHARACTERISTIC FOSSILS.
Pleistocene		Most Northern and Mountainous Counties.	Elephas primigenius.
Neocene		Near White Sulphur Springs. Meagher Co. Near Missoula, Missoula Co. Near Stevensville, Ravallie Co. Near New Chicago, Granite Co. Near Dillon, Beaverhead Co. Near Toston, Broadwater Co.	Mesohippus. Sequoia longsdorfii. Sequoia n. sp. Alnus. Populus balsamoides. Taxodiumh occidentalis.
Fort Union		Near Miles City, Custer Co. Near Livingston, Park Co. Near Melville, Sweetgrass Co.	Many leaves in Sandstone, such as the Oak, Ivy, Willow, Chestnut, Laurel, etc.
Laramie		Near Bear Creek, Carbon Co., and many outcrops are found in Granite, Fergus, Meagher, Sweetgrass, Yellowstone, Gallatin, Park, Madison, Valley, Chouteau, Dawson, Teton, Custer, Rosebud and Beaverhead Counties.	Viviparus retusus. Viviparus trochiformis. Campeloma multi lineata. Unio. Leaves in red shale such as Quercus (Oak) Salix (Willow, etc.) Populus (Poplars, etc.) Ficus (Figs, etc.) Viburnum (Honey Suckles, etc.)
Montana	Fox Hills..	Cedar Creek, Custer Co. Cedar Creek, Dawson Co. Big Box Elder Creek, Custer Co. Castle Butte, near Forsyth, Rosebud Co., and many other places.	Baculites grandis. Belemnitella bulbosa. Scaphites nicolletii. Scaphites cheyennensis. Scaphites conradi.
	Fort Pierre	Cedar Creek, Custer Co. Cedar Creek, Dawson Co. Cabin Creek, Custer Co., and many other places.	Hemiaster, Dentalium. Ostrea, Baculites ovatus. Baculites compressus. Inocerannus. Scaphites nodosus var plenus. Nucula, Yodia, Nautlius dakayi. Corbula, etc.
Colorado (Belly River)	Niobara Benton	Colby Gulch near New Chicago, Granite Co.	Glauconia coalvillensis.

PERIODS.	LOCALITIES.	CHARACTERISTIC FOSSILS.
Dakota	Frying Pan Basin, near Dillon, Beaverhead Co.	Goniobasis pealsi.
Kootenai	Sandcoulee, Cascade Co. Near Augusta, Lewis and Clark Co. Near Lewistown, Fergus Co. Northwestern part of Flathead Co.	Sequoia smittiana Zamites montana Zamites apertus. Chiropteris spatulata. Oleandra arctica
Jurassic.....	Near Harlowton, Meagher Co. Near Crockett, Carbon Co. Near Armington, Cascade Co. Near Augusta, Lewis and Clark Co. Near Choteau, Teton Co. North of Black Butte. Tobacco Root Mountains, Madison Co. Near Ennis, Madison Co.	Belemites densus Gryphaea calceola Camptonectes
Triassic (?)..... (Red Beds) Permian	Carbon County, near Crockett, Bowler and Bridger. Big Snowy Mountains, Cascade Co. Near Armington, Cascade Co.	The writer has found no fossils in these beds, but the large gypsum deposits of the state are from this formation.
Carboniferous	Near Armington, Cascade Co. Ruby Mountains, Madison Co. Bridger Mountains, Gallatin Co. Near Lewistown, Fergus Co. Snow Crest Range. Frying Pan Basin, near Augusta. Near Dillon, Beaverhead Co. Dupuyer Creek, Teton Co. Opposite Logan, Gallatin Co. Old Baldy, South of Virginia City, Madison Co. Sheep Mountain, south of Old Baldy. Spring Canyon, Ruby Mountains, Madison Co.	 Straperallis sp. Spirifer grimensi Platycrinus bridgerensis Spirifer centronata. Productus elegans Athyris crossicardinalis Zaphrentis
Devonian	Near Logan, Gallatin Co. North of Three Forks, Gallatin Co West of Three Forks, Gallatin Co.	Spirifer disjunctus Orthis sp., etc.
Silurian	Near Philipsburg, Granite Co.	Bachiopods
Cambrian	Near Logan, North side of Gallatin River, Gallatin Co. Ruby Mountains, Madison Co.	Asphescus wheeleri Worm casts Corals
Archaean	The Archaean is found in most of the Counties embracing the Rocky Mountains, and West.	

RECOGNIZED GEOLOGICAL FORMATIONS OF MONTANA.

The following gives the various geological formations of the state, as now recognized, with one or two new ones proposed by Prof. Jesse P. Rowe, Ph. D.:

Age	Formations	Thickness in Feet	Characteristic Rocks
Quarternary	Alluvian	0-50	River-sand and gravel
	Glacial drift	0-100	Bowlders, unstratified or slightly stratified deposits of gravel, bowlders, sand, etc., unassorted.
Tertiary..... (Neocene)	Smith River beds	0-800	Clay, Volcanic Ash, Conglomerate, etc.
Cretaceous	Livingston	3300	Shale, conglomerate, dark-brown tufaceous sandstone.
	Laramie	900-1050	Sandstone, red shales.
	Fox Hills Fort Pierre		Gray shales, limestone concretions containing invertebrate fossils.
	Niobrara Benton	3000 to 4000	Black bituminous shales.
	Dakota.....		Quartzite, sandy shale, etc.
	Kootenai (Cascade) (Lower Cretaceana)		Sandstone. Coal deposits.
Jurassic.....	Ellis	90-120	Arenaceous limestone and shale; conglomerate.
Triassic(?) "Red Beds" Permian	Bowler	400 to 500	Red shales and sandstones, thick beds of gypsum.
Mississippian	Quadrant	1400	Alternating beds of limestone and sandstone. Green shale. Limestone with sandstone beds. Green shale and limestones, often oolitic. Red clay.
	Madison	1025	Massive and white Limestone above, thin-bedded and dark grey below.
Devonian and Silurian	Monarch	165	Brown, granular limestone.

Cambrain..... (middle)	Gallatin (limestone) Flathead (quartzite)	1300	Limestone, massive and thin-bedded. Quartzite, (pink) and sandstone.
Proterozoic..... (Algonkian)	Spokane shale	210	Red shale.
	Greyson shales	950	Gray shale and slate.
	Newland limestone	560	Bluish gray with inter-bedded slate.
	Chamberlain shale	2080	Slate and dark gray shale.
	Neihart quartzite	700	Massive bedded.
Archean.....			Gneiss, mica schist and intrusive rocks.

* The wavy lines signify unconformity of strata.

COMPARATIVE COAL ANALYSES.

The bituminous coals of the state compare favorably with those of the east, as shown by the following tables of tests and table of analyses:

PRACTICAL TESTS.

DISTRICT	Character of Coal	THEORETICAL			STATIONERY BOILER TESTS		
		Calorific Power (B. T. U.) Per Pound.....	Evaporation from and at 212 deg.—Lbs.....	Relative efficiency—Per Ct.	Actual Evaporation at Working Temperature and Pressure—Lbs..	Evaporation from and at 212 deg—Lbs.....	Relative Efficiency—Per Ct...
Youghiogheny, Pa....	Bituminous.....	13,860	14,351	100	-683	8.17	100
Youghiogheny, Pa....	Bituminous.....	14,053	14,551	101	6.99	8.37	102
West Virginia	Bituminous.....	14,054	14,552	101.4	6.57	7.90	104.3
Moon Ridge	Bituminous.....	13,888	14,380	99.9	6.83	8.21	108.6
Arnold Ridge	Coking.....	13,766	14,253	98.9	6.85	8.20	108.7
Shenanga, Pa.	Bituminous.....	13,284	13,754	96.4	5.87	7.07	93.5
Hocking Valley	Bituminous.....	11,829	12,248	89.7	5.73	6.87	92.1
Horr, Mont.....	Coking.....	12,984	13,443	93	6.18	7.40	100.7
Bozeman, Mont.....	Bituminous.....	12,113	12,542	88.4	5.30	6.34	84.6
Rocky Fork	Semi-bituminous.....	10,553	10,926	80	5.82	6.97	94.6
Rocky Fork	Semi-bituminous.....	10, 793	11,175	81.2	5.79	6.93	93.4
Rocky Fork	Semi-bituminous.....	10,434	10,802	8.11	5.30	6.36	86.1
Trail Creek	Semi-bituminous.....	.....	.....	.....	5.79	6.88	86.1
Clark's Fork, Mont..	Lignitic.....	10,545	10,918	79.7	4.82	5.79	78.3
Miles City, Mont.....	Lignitic of Plains....	7,721	7,994	.....	3.60	4.32	60.5
Rock Springs, Wyo..	Semi-bituminous.....	11,861	12,281	89.7	5.90	7.11	95.6
Carbon	Semi-bituminous.....	11,750	12,166	85.6	5.23	6.27	84.2
Roslyn, Wash.	Semi-bituminous.....	12,382	12,821	90	5.66	6.77	90.5
Wilkinson, Wash. ...	Coking.....	12,706	13,156	91.1	5.76	6.91	92.6

Locomotive Tests.

DISTRICT	Character of Coal	MOGUL LOCOMOTIVE TEST			CONSOLIDATION LOCOMOTIVE TEST		
		Actual Evaporation at Working Temperature and Pressure—Lbs.	Evaporation from and at 212 deg—Lbs	Relative Efficiency	Actual Evaporation at Working Temperature and Pressure—Lbs.	Evaporation from and at 212 deg—Lbs	Relative Efficiency—Per Ct.
Youghiogheny, Pa...	Bituminous	6.90	8.35	100	6.94	8.42	100
Youghiogheny, Pa....	Bituminous	7.42	8.98	107.5	7.63	9.27	110.1
West Virginia.	Bituminous	5.96	7.30	94	8.	9.71	106.6
Moon Ridge	Bituminous	5.77	7.08	91.2	7.47	9.07	99.5
Arnold Ridge	Coking	6.62	8.06	103.8	7.59	9.19	100.8
Shenango, Pa.	Bituminous	5.56	6.81	87.7	7.74	8.21	90.1
Hocking Valley	Bituminous	5.08	6.21	80	5.96	7.21	79.1
Horr, Mont.	Coking				5.67	6.81	74.7
Bozeman, Mont.	Bituminous	5.15	6.27	80.8	5.86	7.14	78.3
Rocky Fork	Semi-Bituminous	4.97	6.06	78	5.52	6.74	74
Rocky Fork	Semi-Bituminous	5.30	6.47	83.2	5.57	6.80	74.5
Rocky Fork	Semi-Bituminous	4.57	5.55	71.5	5.65	6.83	75.5
Trail Creek	Semi-Bituminous	5.14	6.25	80.5	5.02	6.16	67.6
Clark's Fork, Mont..	Lignitic	4.70	5.73	73.8	5.37	6.54	71.8
Miles City, Mont.	Lignitic of Plains						
Rock Springs, Wyo.	Semi-Bituminous	5.29	6.46	83.5	5.96	7.24	79.5
Carbon	Semi-Bituminous	3.62	4.43	57	6.03	7.35	80.5
Roslyn, Wash.	Semi-Bituminous	4.99	6.08	78.3	6.02	7.33	80.4
Wilkinson, Wash.	Coking	4.62	5.62	72.4	6.47	7.88	86.5

Comparative Analysis.

FIELD	Character of Coal	Water	Volatile Combustible Matter	Fixed Carbon	Ash	Fuel Ratio
CLARK'S FORK—						
(Upper Measure)	Lignitic	6.53	38.22	48.33	6.92	1.26
(Upper Measure)	Lignitic	6.86	37.54	47.07	8.53	1.25
(Upper Measure)	Lignitic	6.02	37.30	46.28	10.40	1.24
CLARK'S FORK—						
(Lower Measure)	Lignitic	4.42	32.36	44.19	19.03	1.37
(Lower Measure)	Lignitic	5.47	34.20	43.95	16.38	1.29
Yellowstone	Coking	1.02	38.01	48.20	11.87	1.27
Yellowstone	Semi-coking	2.14	37.01	55[54	5.31	1.50
Horr	Coking	.67	30.90	57.56	10.87	1.86
Horr	Semi-anthra	1.02	18.77	75.87	4.34	4.04
Trail Creek	Lignitic	10.51	31.87	49.22	8.57	1.54
Trail Creek	Lignitic	7.70	37.11	45.00	10.19	1.21
Belt Mountain	Semi-coking	3.68	25.43	58.05	11.71	2.28
Bull Mountain	Dry Lignitic	7.84	42.71	42.65	6.80	9.91
Bull Mountain	Dry Lignitic	6.42	38.54	49.94	5.10	1.30
Eastern	Lignitic	21.11	28.55	44.98	5.01	1.58

Summary of Chemical Tests.

No.	NAME OF COAL	Combustible			Moisture	Ash	Heat Units—Calories.	Combustible—B. T. U.
		Volatile	Fixed Carbon.	Total				
1	Trail Creek (Mt. House), Nut..	25.92	48.85	74.77	9.04	16.19	7534	13,562
2	Trail Creek (Mt. House), Lump	25.34	52.62	77.96	8.75	13.29	7734	13,921
3	Red Lodge, Lump	26.24	52.39	78.63	9.23	12.14	7245	13,042
4	Bridger, Lump	26.55	54.	80.55	7.67	11.78	7465	13,438
5	Sheridan, Wyo., Lump	26.78	46.40	73.18	21.2	5.62	7006	12,611
6	Red Lodge, Washed Nut	26.15	53.52	79.67	9.05	11.28	7205	12,970
7	Chestnut, Washed Mine Run..	23.10	56.18	73.28	8.64	18.08	8407	15,133
8	Gebo, Lump	21.46	47.40	68.86	6.42	24.72	8241	14,834
9	Bridger, Nut	30.00	50.64	80.64	3.95	15.41	7195	12,952
10	Trail Creek (Kountz's) Lump..	26.24	47.65	73.89	12.41	13.70	7195	12,901
11	Belt, Washed Nut	22.65	55.00	77.65	4.23	18.12	7445	13,402
12	Galt, Canada, Lump	24.28	57.45	81.73	8.00	10.27	7421	13,359
13	Rock Springs, Wyo., Lump....	27.90	61.31	89.21	5.64	5.15	7686	13,836
14	Mountainside, Mine Run.....	26.84	39.91	76.75	2.71	20.54	7918	14,252

Summary of Efficiencies.

No.	NAME OF COAL	Evaperatiofrom and at 212 deg. F..	Cost to Evaporate 1,000 Lbs. Water,..	*Relative Value.....	B. T. U. of Coal.....	Boiler Efficiency.....
1	Trail Creek (Mt. House), Nut	4.65	$0.306	$2.68	10,141	44.27
2	Trail Creek (Mt. House), Lump	5.70	.36	3.28	10,863	50.
3	Red Lodge, Lump	6.50	.345	3.74	10,255	61.
4	Bridger, Lump	6.10	.371	3.51	10,824	54.3
5	Sheridan, Wyoming, Lump	5.01	.547	2.88	9,229	52.4
6	Red Lodge, Washed Nut	5.40	.346	3.11	10,332	50.6
7	Chestnut, Washed Mine Run	5.30	.288	3.06	11,090	46.5
8	Gebo, Lump	5.75	.346	3.31	10,215	54.4
9	Bridger, Nut	4.86	.386	2.80	10,444	44.8
10	Trail Creek, (Kountz's) Lump	5.44	.413	3.13	9,533	55.
11	Belt, Washed Nut	5.60	.40	3.22	10,406	52.
12	Galt, Canada, Lump	6.05	.535	3.49	10,919	53.1
13	Rock Springs, Wyo., Lump	7.55	.448	4.35	12,343	59.
14	Mountainside, Mine Run	5.78	.294	3.32	10,938	51.

Almost all of the eastern prairie portion of the state is underlain with measures of lignite of excellent quality, the fields being an extension of the lignitic areas of North Dakota, but the quality, as shown by the analyses, is very much superior to that of the latter state. The coal beds run in thickness from a few inches to over twenty feet some places lying near the surface and in others being at considerable depth. Except in the foothills and mountainous districts, the coal seams are in horizontal position.

The Rocky Fork field, situated in the southwestern central portion of Carbon county, is known as one of the most productive of good coal in the state, though the distinctive field is small in area. There are also several seams of good coal varying in thickness from four to eight feet in the Red Lodge and Bear Creek areas, which are locally placed in the same formation and are so credited by some authorities; but Prof. Jesse P. Rowe, Ph. D., asserts that the Red Lodge area is entirely separate and distinct from the Bear Creek formation, but belonging to the Rocky Fork field.

What is termed the Yellowstone field, lies largely within Gallatin and Park counties, but also extends into Broadwater, Sweet Grass and Meagher counties. The field produces an excellent steam and also coking coal. The principal points of production of this area are Chestnut, Mountainside and Storrs. This field is locally subdivided into four and is more familiar under such description.

The Trail Creek field lies ten miles south of Bozeman and is connected with the Northern Pacific railway by a spur that runs to Mountainside. There are three working mines in this district, and though there are three seams of workable thickness, but two of these running from four to twelve feet in thickness, have been opened. The coal is semi-bituminous and of excellent quality.

The Cinnabar field is not large in extent and lies just north of the National Park, in the southern part of Park county, and is cut by the Yellowstone river. There are four coal seams in the field, all of workable thickness, running up to five and a half feet. All of the coal of this field is excellent in quality and much of it is a good coking coal.

What is termed the West Gallatin field is in the southwest corner of Gallatin county and extending over into Madison county. The field is not large and apparently much broken, but as

little prospecting has been done little definite knowledge of the coal beds has been secured, the few openings that have been made, however, securing coal of good quality and in measures from four to six feet in thickness. While the field is not large in area, it is problable that, when given railway facilities, it will develop some good coal producers.

Though the Toston field is productive of some of the best coal of the state, the area is small and the seams are narrow, and while workable in a small way, could not be made productive of large tonnage at small cost. Some of the coal has good coking properties.

The Ruby Valley field lies northeast of Virginia City and is about thirty miles west of the Gallatin field, and owing to its present lack of shipping facilities has been but little prospected and not developed at all, but in such openings as have been made into the measures shows a good bituminous coal. Lying to the east of this area there is a small field of semi-anthracite coal.

The Great Falls-Belt field covers a great area of bench and foothill country, running in a great band east and west through Cascade county and projecting east as far as Lewistown in Fergus county, running northwest through the northern part of Lewis and Clark county, and north through the center of Teton county to and beyond the international boundary line. The measure throughout all these counties is of workable thickness, running in places up to 20 feet, the thickest part of the field, so far as revealed by development, being in the immediate vicinity of Belt and Sand Coulee. The coal produced is of both coking and steam varieties. This field is extensively worked at Belt and Sand Coulee, in Cascade county, and has many small openings throughout the most of its area, where fuel for the domestic use of the immediate vicinity is extracted.

The Flathead field is divided into three districts, the North, South and Middle Forks of the Flathead river. The fields have the present disadvantage of being remote from railway facilities and, aside from some development work that was done some years ago in the North Fork field, the areas have been but little prospected. It is assured, however, that the veins are of good workable thickness and that the coal is an excellent quality of lignite.

The Sweet Grass Hills field lies wholly in the northwestern part of Chouteau county, and has only been opened by a few pros-

pect holes, but these have demonstrated that the coal is of the semi-bituminous character. The field lies about twenty-five miles from the main line of the Great Northern railway.

The Judith Basin field is credited with being a continuance of the Great Falls-Belt field and stretches northwest and southeast between Gilt Edge and Lewistown, in Fergus county. Both sides of the bed have been opened in several places, demonstrating the workable thickness of the veins and that the coal is semi-bituminous and bituminous.

The coal area lying along Deep Creek or Smith river, while being prospected in a small way at several points, owing to its distance from railways, has not been developed sufficiently to warrant a statement as to the thickness of the veins or extent of area. The coal is semi-bituminous.

Aside from the Flathead field, the coal measures of the western side of the main range of the Rocky mountains are principally in Missoula, Ravalli and Granite counties, and are termed the Neocene Lake Beds. The coal is an excellent quality of lignite, but lies in seams running from a few inches in thickness to several feet. The coal is mined at several points for local uses, but none of the areas have been developed to any extent.

The counties of the eastern part of the state, and which are not included in the classification of these fields, are all underlain with coal that in the future will be an important factor in the fuel supply of the state.

Jesse P. Rowe, Ph. D., Professor of Physics and Geology at the University of Montana, in his bulletin on "Montana Coal and Lignite Deposits," says: "All but three counties—Silver Bow, Sanders and Jefferson—have coal or lignite deposits that as soon as developed will be of commercial value. Few states can boast of such a distribution of natural fuel. In the eastern part of the state, the ranchers, and the townspeople as well, burn only lignite. Any one living on the plains and desiring a load of fuel, simply drives to his favorite and nearby lignite seam and procures it. This is indeed a blessing. With no timber to speak of within miles and often remote from the railway, the people are permitted to live and develop this great country without worry and with but little trouble in securing the much needed article in the development of every country—fuel."

Chemical Analysis and Fuel Ratios.

The following chemical analyses and fuel ratios are taken from the article of Prof. Jesse P. Rowe, Ph. D., on the coal deposits of Montana:

LOCALITY	Moisture.....	Vol. Comb. Matter	Fixed Carb...	Ash.....	Total.....	*Fuel Ratio...
Red Lodge	2.42	36.701	50.054	10.823	99.998	1.3
Belt	2.23	22.650	55.000	18.12	100.000	2.4
Miles City	14.72	34.439	42.928	7.88	99.999	1.2
Chestnut	8.64	23.100	50.18	18.08	100.000	2.4
Anaconda	5.00	45.000	35.00	15.04	100.000	.8
Drummond	8.25	41.531	36.117	14.101	99.999	.9
Augusta	1.763	50.770	45.914	11.552	99.999	1.1
Wibaux	14.925	39.406	42.200	1.475	100.000	1.07
Cameron	5.282	5.634	84.671	4.412	99.999	15.
Sixteen Mile Creek	1.207	47.280	43.728	7.784	99.999	.9
Aldridge	.97	30.606	58.00	10.43	100.000	1.9
Bull Mountain Field	7.84	42.710	42.65	6.80	100.000	.99
Darby	17.68	19.290	38.803	24.226	99.999	2.
Forsyth	9.516	38.212	44.724	7.547	99.999	1.1
Birch Creek	9.077	37.866	39.693	13.364	100.000	1.
Columbia Falls	1.27	52.077	35.415	11.237	99.999	.7
Sandcoulee	3.66	30.880	55.500	9.96	100.000	1.8
Missoula	9.31	41.170	39.60	9.92	100.000	.96
Havre	15.225	35.490	39.24	10.00	99.955	1.
Lewistown	3.24	35.600	52.72	8.44	100.000	1.5
Culbertson	12.44	36.200	43.11	8.21	99.96	1.3
Trail Creek	10.51	31.870	49.22	8.57	100.170	1.54
Bridger	7.67	26.550	54.00	11.78	100.000	2.03
Gebo	6.42	21.460	47.40	24.72	100.00	2.2
Mountainside	2.71	26.840	49.91	20.54	100.00	1.8
Sanford	1.30	61.430	32.137	5.18	100.047	.52
Spring Creek	3.02	37.842	54.693	4.51	100.065	1.4
Havre No. 2	4.44	50.64	37.01	7.86	99.95	.73

* The fuel ratio is obtained by dividing the percentage of Fixed Carbon by the percentage of Volatile Matter.

CARBON MONOXIDE GAS.

Considerable space in this report is devoted to the publication of information relative to carbon monoxide and other mine gases, their detection, modes of dissipation and the treatment of those poisoned by their inhalation, and it will be noticed that many of the authorities disagree on many vital points covered by the general subject. It is believed by the department that the matter produced will be of material value to the mine operator and to the mine worker, and that it will result in the future saving of many lives and avoid much expensive conflict between the employer and the employed; and it is hoped that the agitation of the subject, and the gathering together of authorities and experiences, will awaken an interest that will result in securing a more delicate and certain method of detecting small percentages of carbon monoxide, than the means at present employed.

The information presented has been gathered with some painstaking and labor, and it is either from the most excellent professional or practical authority. It will be noticed that aside from such eminent authorities as Dr. Haldane, Sir Foster and Dr. Miller, there seems to be little practaciable knowledge, even among mine managers of large experience, of carbon monoxide, the most deadly and insidious of mine gases, as to what percentage of the gas in mine atmospheres is either deleterious or dangerous to human life, or how best to detect the presence of the gas. The assertion is made in some cases that a percentage would not be at all dangerous, when it has been positively demonstrated that a much smaller percentage would be fatal; others do not at all appreciate the insidious character or deadly effects of the poison. While, in our many coal mine accidents that prove fatal to so many miners in each instance, the deaths are attributed to the much less dangerous and more easily detected carbon anhydride, or, as commonly called, smoke asphyxiation, when, as a matter of fact, nearly all these deaths are due to carbon monoxide poisoning and also resultant asphyxiation. It may be that a more general knowledge in the premises will not result in the saving of lives directly involved in energetic explosions; but it certainly will result in more prompt and effective rescue work and resuscitation of those who are prostrated with the poisonous gas, but not past the stage of possible recovery.

It is also the hope of this department that, insofar as this state is concerned, the mine operators will conclude, as is evident, that to keep on hand proper equipment for the detection of the gas, appliances that will allow prompt and efficient rescue work and simple remedies for initial resuscitation efforts, will be profitable to them, as well as result, in cases of explosions and fires, in the saving of many lives whose values can not be reckoned in cash.

The careful reading of this department of the report is recommended to every mine superintendent and mine boss and to very doctor who, by reason of his locality, is liable to be called to administer to patients brought from the coal mines, and to every miner who desires better information on these dangers that are always surrounding him during his hours of labor.

Counties and Their Coal.

BEAVERHEAD COUNTY.

The county of Beaverhead is well supplied with coal, though at the present time, on account of their remotenesss from shipping facilities, they are not being developed or worked to any extent, and do not figure in the coal production of the state. The coal is a high grade lignite and is located in two districts, one in the northwestern part of the county and locally known as the Pioneer district, and the second, divided into two areas, named the Medicine Lodge and Horse Prairie districts, these seams lying in the southwestern part of the county. There is another area in the southern part of the county lying east of Monida, but the seams of this area are not thick. The coal measure in both of the districts in the western part of the county, so far as shown by development, run from three to ten feet in thickness. There are, approximately, 4,600 square miles of coal lands in the county.

The department is indebted to Jesse P. Rowe, Ph. D. of the University of Montana, for the analyses of the coals of the different fields, and among these he gives that of the Pioneer field as follows:

BEAR CREEK FIELD, NEAR RED LODGE, MONTANA

Moisture .....11.55 per cent.
Vol. Comb. Matter .....38.25 per cent
Fixed carbon .....39.92 per cent.
Ash .....10.48 per cent.

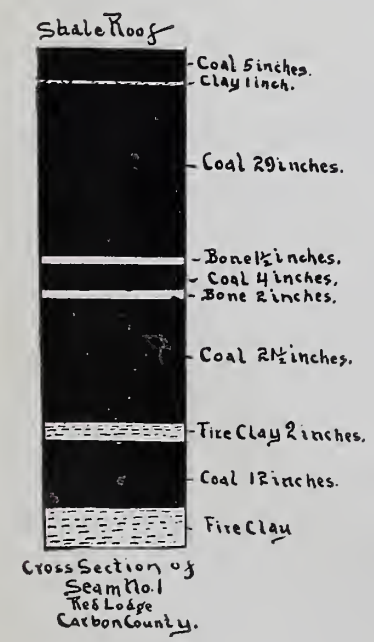
The only coal produced from these fields is for consumption in the immediate vicinity.

BROADWATER COUNTY.

The coal measures of this county are opened in two places. There is a small area south of Toston that has been opened, but while the seams are workable, they are too small to develop into considerable producers. The quality of the coal is good and of the cooking variety. Some Minnesota capitalists are developing on rather a large scale in the neighborhood of Lombard and have opened a seam over seven feet in thickness. This coal is also of good variety and will coke.

CARBON COUNTY.

Carbon county stands second in the state in the production of coal, and while its product now is running well toward a million tons annually, it will be greatly increased during the next couple of years. The county has over 3,000 square miles of determined coal lands, the geological formation of which is Laramie, except that of Red Lodge, which is Fort Union. The western and southern part of the county is mountainous, and the foothills, extending east, give place to bench and prairie. There is an extensive coal field that runs north and south through the center of the county, and a smaller field that lies in about the center of the county, but west of the other field. This field is known as the Clarks Fork field. The gross production of the county for 1905 was 646,367 short tons, and for ten months of the present year, 433,946 short tons.

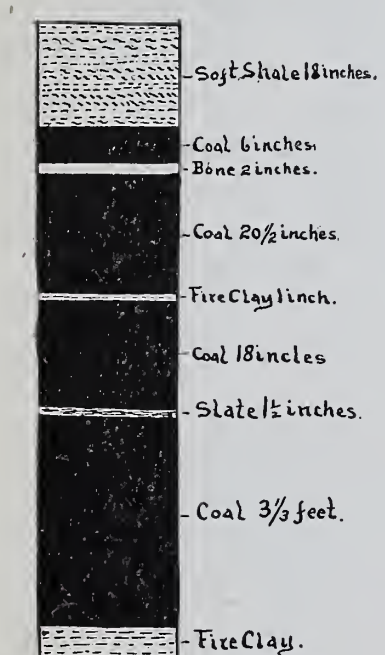


Cross Section of Seam No. 1 Red Lodge Carbon County.

The largest producer among the coal mines of the state is the property of the Northwestern Improvement company, a subsidiary organization organization of the Northern Pacific railway, at Red Lodge. The output of this mine supplies the railway system east as far as Mandan, North Dakota, and west to the state line of Washington, and is in active industrial and domestic demand all over the state. During the summer the company has installed a new dumping and loading plant, using the framework of the old steel tipple as a base. The coal from the No. 2 slope is delivered directly onto the tipple floor, close to the dump; the coal from No. 4 slope is brought up and dropped back to an outside parting. Here a triphaul takes the loaded trip and lands it on the tipple floor, and a chain feed then takes the trip and feeds it to the dump. On the tipple floor a steam car-pusher spots the pit cars on a rotary dump, the coal first having been weighed in the car. After the car is spotted the operator releases the dump, which is turned by means of an electric motor, making one complete rotation and then automatically locking itself into position to receive the next car. This loaded car then pushes the empty off the dump, and it passes down an abrupt slope to the kick-back, and is sent either to No. 2 or No. 4 car haul, a 3-throw switch being located at the kick-back, the latches of which are operated from the dumping platform. The empty cars, after leaving the kick-back, travel by gravity to the empty uphaul chains which raise them over a knuckle and on the No. 2 side, sends them down to the empty trip, where a boy couples and oils them, and after being hooked to the rope, the car-pusher pushes the trip over the slope knuckle. On the No. 4 side the empties are sent by means of the uphaul chains to the downhaul, which delivers them on the outside parting referred to, where a boy couples and oils them and makes them ready for the rope. As the coal is being dumped it falls into a hopper located below the rotary dump and from there is fed into the shaking screens to prepare it for shipment. A fly is located in the hopper, and if coal is desired for locomotive use this gate is thrown over and the coal is delivered into a

Cross Section of Seam No. 1½ Red Lodge Carbon County.

conveyor that takes it to a rubber belt conveyor that runs at right angles to the first conveyor, the belt delivering the coal to a bin located at the side of the railway tracks. If a car of rock is to be dumped, the fly is thrown into the same position as for locomotive coal anl the rock is delivered onto the same rubber belt conveyor, which, at the locomotive bin, is doubled back over two pulleys in such a manner that the outside end of the conveyor is lower than the inner end, and where the belt passes over the higher pulley a chute with a fly gate is located. This chute runs from the higher or inside end to the lower or outgoing end of the conveyor. When rock is coming the fly gate at the head of this chute is closed and the rock passes down the chute and is delivered on the same belt conveyor beyond the two pulleys referred to, and thus does not interfere in any way with the chute that delivers the coal to the locomotive bin. At the extreme end of this rubber belt conveyor, a rock bin is located, into which the rock is dumped, and from the bottom of which it is drawn into an larry car with side and end dumps. The electric larry delivers the rock on the dump about a mile below the plant. As stated, the coal that is to be shipped, is delivered onto shaking screens that deliver the lump coal onto picking tables, where all rock and bone is removed. These picking tables deliver the coal onto a loading table, which delivers the coal into a chute from which it is loaded into the railway cars on the side, or, by means of a gate, under the center of the tipple building. At the side of the building a Smith gravity box car loader operates in this way: A box car is run onto the table or cradle and is held into position by means of moveable iron posts called iron stops. On either side of the table is a circular segment shod with two



Cross Section of Seam No. 2 Red Lodge Carbon County.

Cross Section of Seam No. 4 Re's Lodge Carbon County.

Cross Section of Seam No. 5 Re's Lodge Carbon County

railway rails each, the rails being bent to fit the segments. The segments and consequently the table with its load, are supported on four roller-bearings set in a pit of the proper size. This method of support allows the cradle to be titled at any desired angle, the tilting being accomplished by means of four wire cables, one end of each of which is fastened to the cradle and the other end to the heads of two hydraulic cylinders placed in the pit referred to in such manner that when the cylinders travel to the right, the cables fastened to the left side of the cradle pull that side down, and when they travel to the left the cables on the right side pull that side down. These cylinders are connected with the pump in such manner that both travel exactly alike. The coal that goes through the shaking screens is fed into an elevator that carries the screenings to the top of the building, where they are fed into another set of shaking screens. Everything that passes over this set is fed into six spiral separators which remove all bone and rock and delivers the cleaned coal into a chute, from which it is loaded into cars on the opposite side of the tipple from that on which the box car loader is located. The screenings that pass through these second screens drop into a hopper and are fed into a conveyor that carries them to the washery. The washery is of the Luhrig type and is capable of handling 500 tons of raw material in ten hours. The refuse from the washery is taken away by means of the same electric larry that handles the mine rock, and is delivered at the same rock

DIP OF COAL STRATA AT RED LODGE, MONTANA.

NORTHERN PACIFIC PLANT AT RED LODGE MONTANA

TIPPLE AT BRIDGER, MONTANA

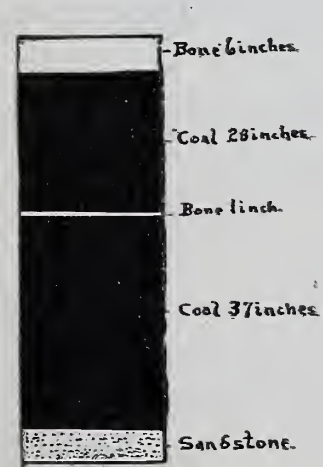
GENERAL VIEW OF PLANT AT STOCKETT, MONTANA.

dump. The machinery of both the surface and underground workings is driven by electric current, and the mines and the plant are lighted by electricity. Eight coal seams have been developed, aggregating a thickness of 60 feet, the dip of the veins being from 16 to 20 degrees. The deepest of the workings are now down 2,500 feet on the incline. The output of the mines for 1905 was 590,035 short tons, the mine having worked 302 days, with 480 inside and 120 outside men; and for ten months of 1906, the production of the mines of the state having been taken up to the last day of October, was 356,573 short tons 209 days having been worked during that period, with 500 inside and 100 outside men.

Following is the analysis of the Red Lodge coal:

Moisture	2.42 per cent.
Vol. combustible matter.....	36.701 per cent.
Fixed carbon	50.054 per cent.
Ash	10.823 per cent.

There are a number of properties at Bear Creek of greater or lesser importance, much development is being done, and the near future will see that part of the field become one of the most important producing districts of the state. Mr. J. C. McCarthy has purchased a considarea of coal land and has leased a contiguous one-half section from the state, a couple of miles northwest of Bear Creek, and has been busily engaged during the season in developing his ground and establishing a modern and convenient working plant, and has succeeded in placing the property in shape for the production of a large and regular output.

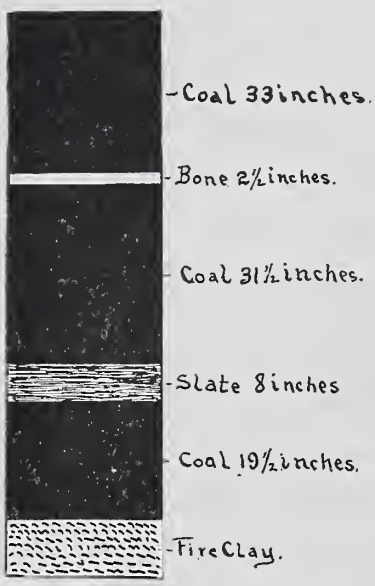


Cross Section of Seam No. 6 Red Lodge Carbon County.

Mr. McCarthy has opened the mine with two main entries that are driven on the vein a distance of 300 feet and has made an upraise to the surface to provide thorough natural ventilation and to give egress from the back of the workings. The seam developed is a clean coal over six feet in thickness, and there is one vein above and at least six veins beneath, making an aggregate coal thickness of over 60 feet, making the possible production of his land holdings run into many millions of tons. The railway company has extended its standard line from Bear Creek to the mines. The Bear Creek coal area is lo-

cated five miles southeast of Red Lodge, and is connected with the main line of the Northern Pacific with a branch running south from Laurel and running easterly from Silesia.

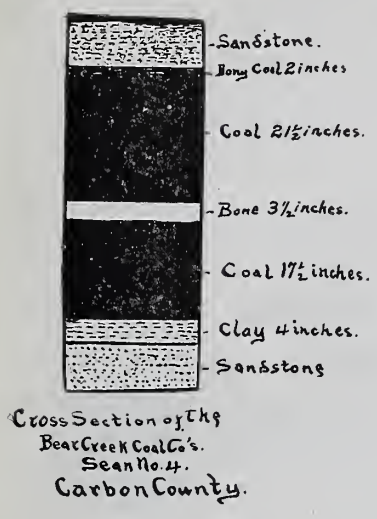
The J. C. McCarthy mines at Fromberg are now being worked under lease by Messrs. Killorn & Weber, had an output of 8,000 short tons, having worked 220 days during 1905, with ten inside and two outside men, and for the ten months of this year, with twelve inside and three outside men, produced 9,000 short tons. The mine is worked on the room and pillar plan. A new slope is being driven and a steam hoist, tipple and screens will be installed, with the other accompaniments of a convenient and modern plant, and the output will be greatly increased and sent into the domestic market.



Cross Section of the Bear Creek [illegible] Seam No. 3 Carbon County.

Another property that has been opened largely during the present year at Bear Creek is that of the International company, which, in doing development work during 1905, had an output of 1,175 tons of coal. The seam being worked is seven feet in thickness.

The Bear Creek Coal company, an organization effected under the incorporation laws of the state, has 800 acres of land that is underlain with eight demonstrated coal veins aggregating over 45 feet in thickness. The development of the ground was commenced during the summer of 1905, and three veins have been opened and prepared to produce coal. The first vein is 6, the second 9½, and the third is 5 feet in thickness. The mine now



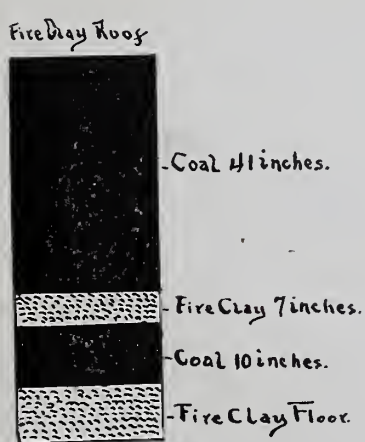
Cross Section of the Bear Creek Coal Co's. Seam No. 4. Carbon County.

has a productive capacity of 2,000 tons per day. The mine and the surface workings are lighted and run exclusively by electricity, being equipped with a McEwan engine and Goodman generator of 250 horsepower. All the hauling is done with Goodman motors, one a third-rail 80 horsepower motor and the other a 50 horsepower traction motor. The plant is so situated that the coal is run on a down grade from the place of mining to the shipping cars. The power house is a substantial stone building 50x150 feet, divided by a stone partition into a 50x50 foot engine rom and a 50x100 foot boiler room. In this room there are two Atlas boilers of 150 horsepower each, and the building is so arranged that the power capacity may be increased to 900 horsepower. The product of the mine is turned into three grades—lump, egg and nut coal. The analysis of the coal is as follows:

Moisture	7 per cent.
Volatile combustible matter	36 per cent.
Fixed carbon	53 per cent.
Ash	4 per cent.

This analysis is made by the company.

The output of the Bear Creek Coal company's mine for the ten months of this year was 2,989 short tons, having worked 60 days during that period, with 75 inside men and 8 outside men.

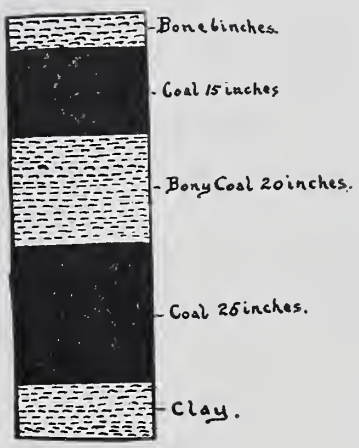


Cross Section of Seam No. 5 Bear Creek Carbon County

There are a number of prospects in this section of the field that give promise of soon developing into regular producers.

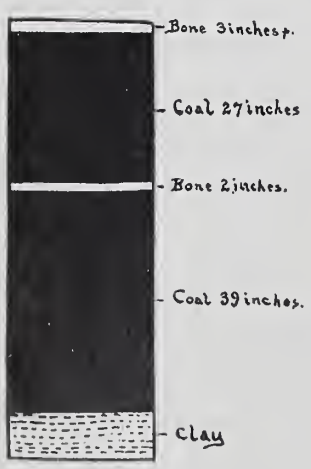
The mines of the Bridger Coal company are situated three miles from the town of Bridger, and are one of the largest producers, the output for 1905 having been 39,417 short tons, working 250 days, with 54 inside and 16 outside men; and the output for the ten months of this year was 35,000 short tons, working 220 days during that period, with 80 inside and 25 outside men. The coal is a good semi-bituminous variety, and the seam that is developed

and worked is seven feet in thickness, capped with a brown sandstone, and lies at a dip of about 12 degrees. The surface and the mine workings are equipped in the most modern way, all machinery being run with electric power and the mine being lighted with electricity. The equipment consists of four 125 horsepower boilers, two 250 horsepower high-speed McEwen engines, Link-Belt electric dynamos supplying power to operate a 250 horsepower electric hoist, one 80 horsepower Link-Belt locomotive, one 60 horsepower Worthington 3-plunger electric pump, seven electric chain breast mine machines and a 30 horsepower electric ventilating fan. The tipple, located some distance from the mine, is equipped with dump, shaking screen and box car loader. There are a number of small properties under development and opening in and about Bridger.



Cross Section of the Bridger Coal & Improvement Co's Mine Carbon County

The Gebo mines are located ten miles north of Bridger on the same line of the Northern Pacific railway, and in the Clarks Fork field, the developed vein being six feet in thickness, the workings now extending down on a 6 degree dip for a distance of 2,500 feet. The coal measure here is capped with shale and sandstone. The coal is of the lignitic bituminous variety. The output for last year was 7,625 short tons, the mine having worked but 146 days, with 30 inside men and 20 outside meen For the ten months of this year the output is 19,384 short tons, having worked during that period 100 days, with 47 inside and 12 outside men. The property is equipped with a steel tipple, shaking screens, etc., and a modern electric plant for driving the hoisting and other machinery and the ventilating fans.



Cross Section of the Gebo Coal Company's Mine Carbon County.

The Smith mines are located at Bear Creek about three and a half miles from Red Lodge, and contain practically the same seams as those of the Bear Creek property. The mine is developed with two

openings, one of which is now being used in the production of coal that is being placed on the market. Production for 1906, 2,000 short tons.

The Joliet Coal & Fuel company's mines are located 2½ miles east of and between Joliet and Gebo. The coal seam is four feet thick and is opened with a drift, the mine being worked on the room and pillar plan, the product being hauled out by mule. The output is largely sold in the immediate vicinity and at Joliet. Output for ten months of 1906, 9,000 short tons.

Cross Section of the Joliet Coal & Fuel Co's Seam Carbon County

The next two years will witness the development of a number of new coal properties at different points in the coal fields of Carbon county, and a great increase in the aggregate output.

CASCADE COUNTY.

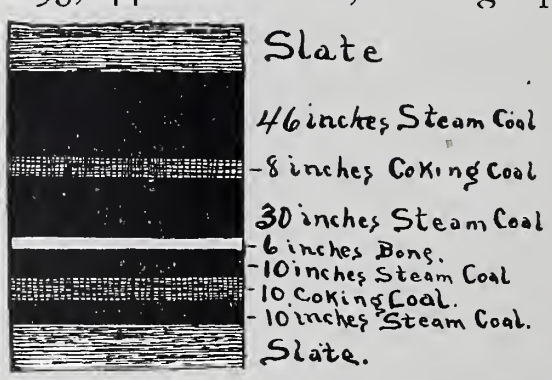
It is estimated that Cascade county has about 3,500 square miles of coal land within its borders, the broad measure running east and west through the entire width of the county, and underlying the foothills and bench lands skirting the north side of the Belt mountain range. The present development is at Sandcoulee, Stockett, Belt and Armington, at which points railway shipping facilities are afforded by branch lines of the Great Northern railway from Great Falls. That portion of the field lying south of Sandcoulee and locally known as the Smith river or Deep creek field, is considerably developed and has been demonstrated to have good coal of the bituminous variety, with the seams running from six to eighteen feet in width, but as the locality is without railway shipping facilities, the extraction of the coal has been limited to the local agricultural consumption. The coal runs about 56 per cent in fixed carbon and 10 per cent in ash. The field lying to the west of Sandcoulee and of the river, and east of Armington, is also unproductive on account of a lack of shipping facilities, but the building of the Burlington railway to Great Falls from Billings, will open much of this eastern area.

So far as demonstrated, the coal bed in all the Cascade county area lies in practically a horizontal position.

Cascade county is the largest producer of the coal counties of the state, the output for 1905 having been 842,550 short tons, and for the ten months of the present year was 838,363 short tons.

Sandcoulee is the oldest coal mining camp in the county and in the northern part of the state, and is located ten miles south of Greaa Falls on a spur of the Great Northern railway, which company originally established the camp and opened the mines for the purpose of supplying the system through Montana, Idaho and North Dakota with coal, and though its ground has been worked out and the plant has been reinstalled at Stockett, several miles south and on the opposite side of the worked bench, Sandcoulee is nevertheless a prosperous producing coal camp, and will be for a great many years to come. The coal measure in the Sandcoulee district lies flat and runs about ten feet in thickness, the coal being a good gas and steam producer.

The mines of the Nelson Coal company, at Sandcoulee, are the largest property now operating in this vicinity. The output of the mines for 1905 was 93,244 short tons, having operated 203



Cross Section Nelson Coal Cos. Mine
Sans Coulee,
Cascade County.

days, with 80 inside and 10 outside men. The product for the ten months of the present year was 78,000 short tons, having worked during that period 290 days, with 60 inside and 10 outside men. The mines have good mechanical ventilation and drainage, and are worked with the pillar and stall system. The following is a cross-section of the company's vein:

The workings are laid with steel rails and the hauling is done by mules, the cars holding one and one-half tons of coal. The

tipple is located about 150 yards from the portal of the main entry, and on a spur of the railway.

The Gerber Coal company, also located at Sandcoulee, is located just south of the Nelson properties, and in 1905 produced with 11 inside and 5 outside men, working 240 days, 13,229 short tons, and during 213 days worked in the ten months of this year, with 12 inside and 3 outside men, produced 32,478 short tons of coal. The analysis of the Sandcoulee coal is as follows:

Moisture	3.66 per cent.
Volatile combustible matter	30.88 per cent.
Fixed carbon	55.50 per cent.
Ash	9.96 per cent.
Total	100.00 per cent.

Mr. Louis Dahn has for several years operated property in the immediate vicinity of Sandcoulee, supplying the local trade. There are a number of prospects that are gradually developing into mines. The future of Sandcoulee as a coal camp will be much greater than in the past.

The Stainsby Latham Coal company are developing a property between Sand Coulee and Stockett. Coal has been hauled by teams to Great Falls market, but a siding has been put in lately on their property and in the future the coal will be shipped by rail. This mine bids fair to becoming a large producer; it certainly will claim its share of the markets, as the coal is of good quality. The report for first ten months of 1906 was 608 tons.

The coal camp of Stockett is three miles south of Sandcoulee, and is the site of operations of the Cottonwood Coal company, a subsidiary concern of the Great Northern railway, and next to the largest individual coal producer in the state. The output of the mine last year was 465,432 short tons, having worked 230 days, with 367 inside and 142 outside men. For the ten months of 1906 the output was 462,040 short tons, the property having been worked 212 days during that period, and with 356 inside and 135 outside men. The equipment of the mine, both on the surface and in the mines, is thoroughly up-to-date, the coal being mined with 36 Harrison mining machines and 12 Rand air drills. The following is a cross-section of the company's coal seam.

Sand stone	Cap rock
Top coal	1 foot 6 inches.
Slate	5 inches.
Top bench	1 foot 6 inches.
Bone	7 inches.
Gray coal	1 foot 3 inches.
Blacksmith coal	2 feet 5 inches.
Bone	6 inches.
Coal	1 foot 5 inches.
Metamorphosed fire clay	
Total coal	7 feet 9 inches.
Refuse	1 foot 6 inches.
Thickness of seam	9 feet 3 inches.

An approximate analysis of the Stockett coking coal is as follows:

Moisture	3.01 per cent.
Volatile combustible matter	29.55 per cent.
Fixed carbon	52.09 per cent.
Ash	15.35 per cent.
Sulphur	1.92 per cent.

Belt is, in point of population, the largest coal camp in Cascade county, and, aside from the mines of the Amalgamated Copper company, has a number of small producers and many prospects that are being developed. Belt is located 24 miles southeast of Great Falls, on the Neihart branch of the Great Northern railway.

The coal mines of the Amalgamated Copper company located at Belt, commenced operations in 1893 and have been continuously in operation since that time, and is now credited with a gross production of over four and three quarter millions tons of coal. The mine is operated by the tail rope system, the rope extending underground about 1½ miles, and some of the coal is hauled fully 2½ miles from point of extraction to the tipple. The mine is equipped with a 500 horsepower air compressor and the greater part of the coal is mined with Ingersoll-Sergeant mining machines. The surface plant includes a tipple capable of dumping 3,500 tons per each ten hours, a 1,000 horsepower steam plant, Luhrig washer, having a daily capacity of 600 tons, a Jeffrey-Robinson washer with a capacity of 1,200 tons per day—the former being originally used for coking coal and the latter for steam coal—100 coke ovens, but these have not been in operation the past season, a modern electric light plant that furnishes the mine, works and town with light, and a water

works system also performing public service. The present output of the mine is about 1,100 tons daily, the output being shipped to the company institutions at Great Falls, Anaconda and Butte. In hauling the coal from the workings the tail rope brings out 48 cars, each containing 2⅓ tons of coal, at a time. The output of the mine for 1905 was 265,744 short tons, having worked 263 days, with 325 inside and 75 outside men. During the ten months of this year, with 296 inside and 68 outside men, the output was 258,547 short tons.

Owing to the extensive operations of the company during the past several years, the workings have advanced until there is a great length of courses and area to ventilate, and while the appliances for artificial ventilation have been large and powerful, the company has found it necessary to assist it by the construction of an upcast driven at an angle of 45 degrees a distance of between 300 and 400 feet, through the country formation, to the surface. This airway will also afford an additional and one of the best avenues of exit in case of accident, and it is the opinion of the department that it will create perfect ventilation in the workings.

The output of the mines goes wholly to the smelters of the company at Anaconda and Great Falls.

Orr Brothers are operating a mine about one and a half miles north of Belt, opening on Belt creek, and produced about a thousand tons of coal last year and 2,000 tons this year, marketing their product at Belt and doing some shipping to outside towns.

Colone & Schmauch are operating the old Frank Lewis mine and are marketing their product with the surrounding ranchers and in the town of Belt.

The Millard mine, which is one of the oldest coal openings in this part of the field, is being worked in a limited way, marketing the product in the immediate vicinity.

Mr. Matt Richardson's mine, located across Belt creek, at Armington, is working steadily and disposing of the output in the town, surrounding country and for such fuel as is required along the Burlington railway that is being constructed through that vicinity. The mine has promise of becoming a good and steady producer.

CHOUTEAU COUNTY.

Chouteau county is one of the prairie counties of the state, though it has within its borders several small and isolated ranges of mountains. There is a large part of the county underlain with an excellent quality of lignitic coal, with seams of good, workable thickness. The center of the field is crossed by the main line of the Great Northern railway, and the southern portion is crossed by the Montana Central, running from Havre southeast to Great Falls and beyond. Little actual development of the measure and no mining, other than the extraction made by individuals for their own use, has been done except at Fort Benton and Havre, there being several working mines at the latter place, and there are two mines being opened at Big Sandy, about half way, on the Montana Central, between Havre and Fort Benton. The record of production for 1905 was but 3,500 short tons, and for the ten months period of 1906, 5,000 short tons. An approximate analysis of the coal is as follows:

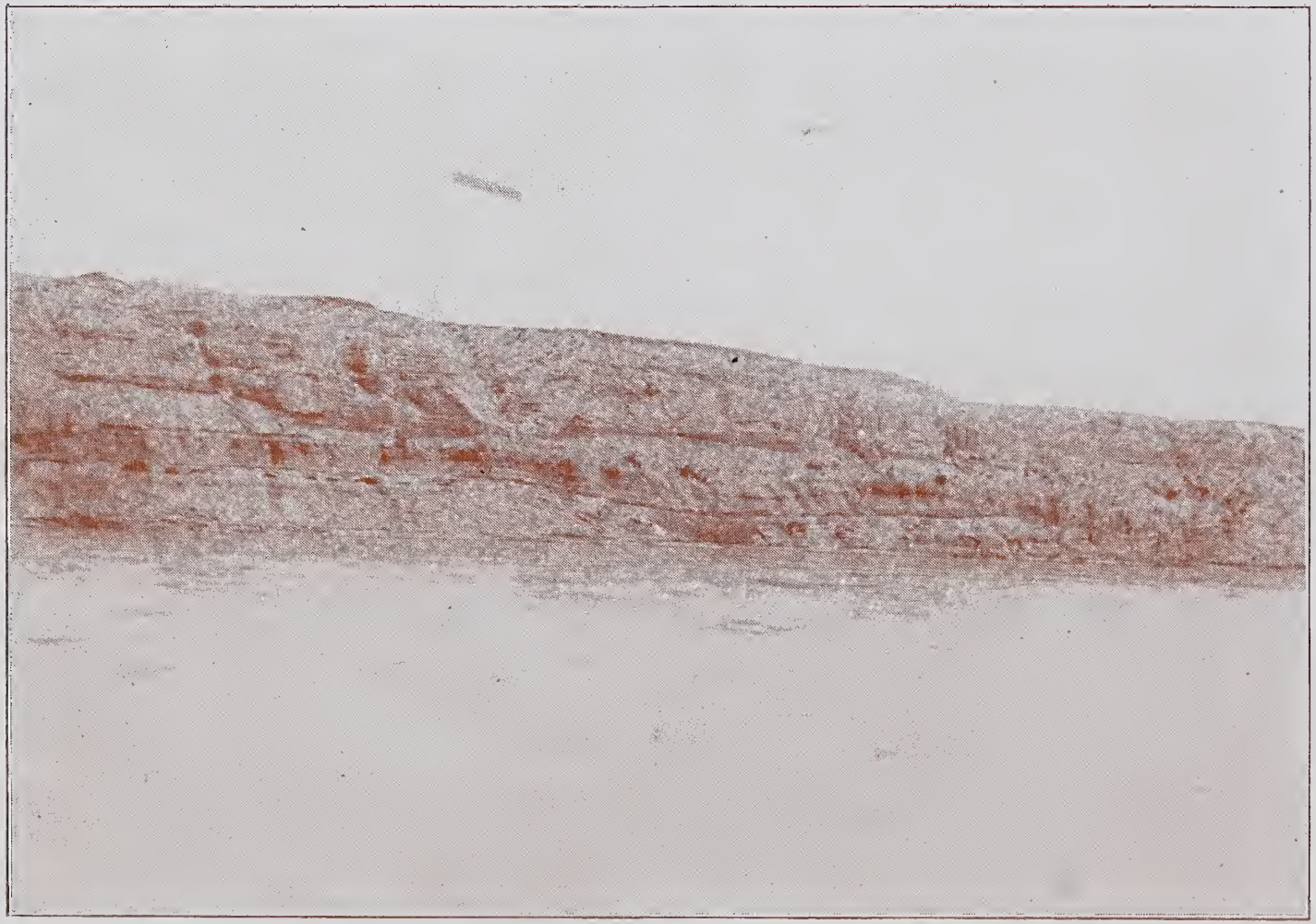
Moisture	15.225 per cent.
Volatile combustible matter	35.490 per cent.
Fixed carbon	39.240 per cent.
Ash	10.000 per cent.

There will unquestionably be considerable activity during the next couple of years in the opening of mines in different parts of the field that are tributary to shipping facilities, and the output will be largely increased.

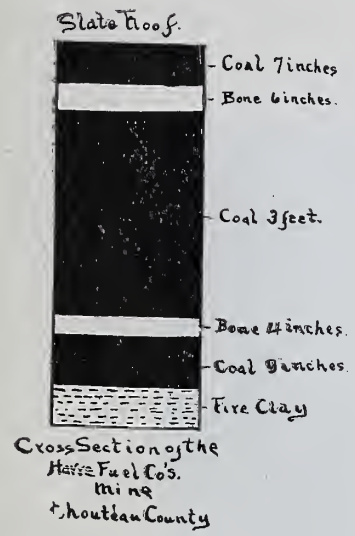
The Havre Fuel company's property is located three miles north of the city, where the measure is much thicked than to the south of the town. The lands being operated by the company are owned by the state and are worked on a royalty basis. The coal seam is opened by an entry drive on the dip of the vein, and is equipped with a steam hoist, tipple and bunker, these being recently installed with a view to greatly increasing the output of the mine, which is now marketing its coal at Havre, points along the railway east, and as far west as Spokane, Wash.

TIPPLE AND MINE OPENING NEAR HAVRE, MONTANA.

COAL PROPERTY NEAR MILES CITY, MONTANA



STRIKE OF COAL VEIN ON YELLOWSTONE RIVER, NEAR MILES CITY.



Cross Section of the Havre Fuel Co's. mine Chouteau County

The management of the company is making arrangements to enter all the markets tributary to its field, and expects to continually increase the capacity of the mine and working plant. The high price of wood throughout the northern part of the state, the distance from the larger operating mines of Cascade county and along the Northern Pacific, and the excellent quality of the output of this mine, assures the future importance of this producer. The output for 1905 was 2,000 short tons, and for the ten months of this year 3,000 short tons.

The Alcot mine, also north of Havre, promises to develop largely in the near future, having had an output for 1905 of 1,000 short tons and for the ten months of this year, 400 short tons.

Mr. Adam Hadalin is also opening a coal property north of Havre.

There are two properties being opened at Big Sandy, one by Mr. C. C. Mack and the other by Mr. James Frame, both of which are promising propositions.

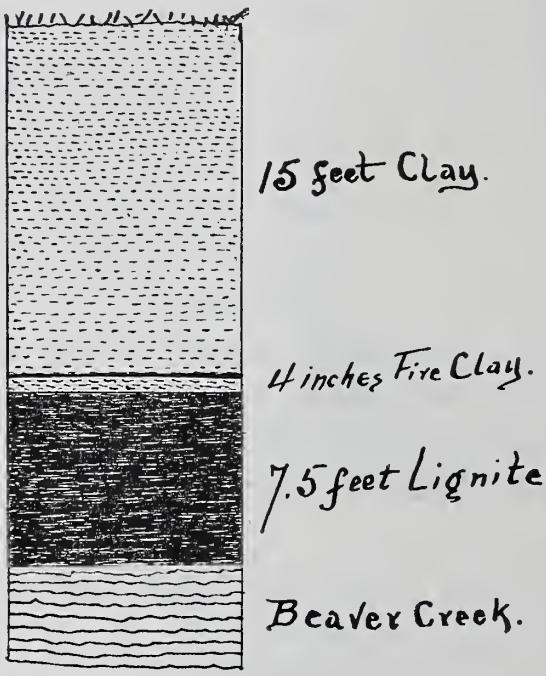
There are several small openings in the vicinity of Fort Benton, and these furnish the coal for the immediate vicinity.

It is demonstrated that the coal area of Chouteau county extends as far south as Shonkin creek in the Highwood mountains, as far east as Box Elder, and as far north as Concord.

CUSTER COUNTY.

Custer county, though one of the largest of the many large counties of the state, is almost wholly underlain with a fine quality of lignite that lays in the thickest seams, in places, to be found in the coal areas of the state. The thickest seams in the northern part of the county are found in the vicinity of Coal and Lignite creeks, where they run from six to eight feet, and the quality is good. South and west of Beaver creek, near Ekalaka, are good lignite croppings, but no development has been done in this part of the field whatever, other than coal extracted for the use of the town of Ekalaka. The quality is good, and the

vein worked several feet in thickness. Southwest of Ekalaka, along the Powder river, the lignite outcrops in many places. There are two seams in this vicinity and along the Little Powder river. The lignite in this county belongs to the Laramie formation. The most activity in coal mining is in the neighborhood of Miles City, where there are several mines engaged in supplying the local fuel demand. The seam most developed in this vicin-



Cross Section Lignite Seam, 21 Miles S.W of Wibaux, Custer County.

ity is about four feet in thickness and lies about 45 feet beneath the surface, and is developed with an entry-way driven on the incline. The following is the analysis of an average sample of the coal produced in this vicinity:

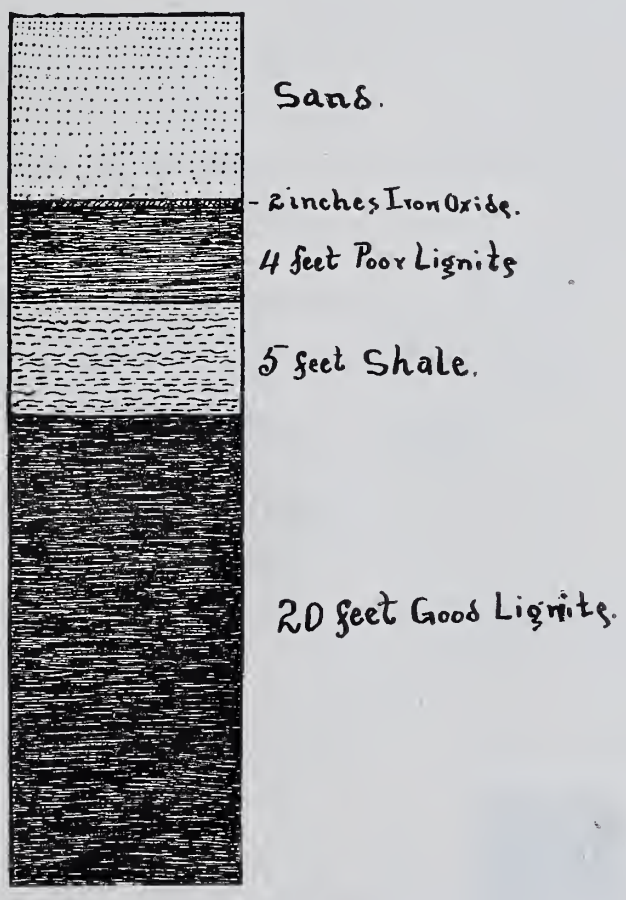
Moisture	14.572 per cent.
Volatile combustible matter	34.439 per cent.
Fixed carbon	42.439 per cent.
Ash	7.880 per cent.

DAWSON COUNTY.

Dawson county is situated in the extreme eastern part of the state and between Valley on the north and Custer on the south, and its entire area, except its western portion, is underlain with lignite of fine quality. On the west bank of Beaver creek, in the

LIGNITE OUTCROP, 20 FEET THICK, GLENDIVE CREEK, DAWSON COUNTY.

extreme southeastern part of the county, there is an outcrop of lignite ten feet in thickness. Though there are openings in many places remote from the railway, where ranchers secure their fuel, and in the neighborhood of Wibaux, where fuel for the town and immediate vicinity is produced, there has been little real development of the field except in the vicinity of Glendive,



Cross Section Lignite Seam on Head of Glendive Creek, Dawson County.

where, on Glendive creek, the seam shows twenty feet thick and is thought to cover a large area. There are large deposits along the Missouri river that show from ten to fifteen feet in thickness. The lignite beds crop everywhere in the Big Dry country, and farmers all have their own mine. There are some openings at Sanford, in the southwestern part of the county, and the seams are shown to be of good thickness as well as quality of coal. The analysis of the Dawson coal area coal is as follows:

Moisture	14.925 per cent.
Volatile combustible matter	39.400 per cent.
Fixed carbon	42.200 per cent.
Ash	1.475 per cent.

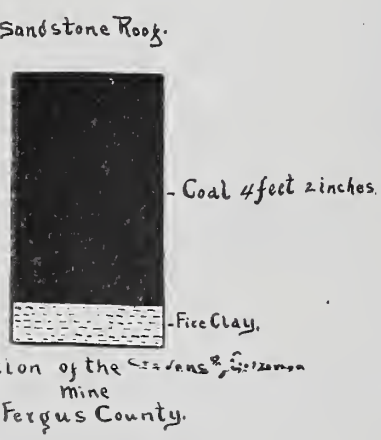
DEER LODGE COUNTY.

Deer Lodge county, lying on the west side of the Rockies, has during the past year proved that it contains coal, but the extent of the area or the continuity of the measure opened has not as yet been demonstrated. There has been some work done in developing the Black Diamond mine, which is located but a short distance from the old Anaconda smelters. The coal is a lignitic bitmuinous variety. One of the seams opened is five feet thick, but little exploration has been made in it. The coal analysis is as follows:

Moisture	5.00 per cent.
Volatile combustible matter	45.00 per cent.
Fixed carbon	35.00 per cent.
Ash	15.00 per cent.

FERGUS COUNTY.

Fergus county is located in almost the center of the state, is one of the largest counties of the state, and its citizens proudly call it the Inland Empire. The Great Falls field is extended through the central portion of this county for a distance of some fifty miles, the coal measure being from ten to fifteen miles in width. Another coal area lies north and east of Lewistown, extending down to the Snowy mountains. The coal is of the semi-bituminous variety, and is found in the Kootenai formation.



Cross Section of the Stevens & Solomon mine Fergus County.

The analysis of the coal near Lewistown is as follows:

Moisture	3.24 per cent.
Volatile combustible matter	35.60 per cent.
Fixed carbon	52.72 per cent.
Ash	8.44 per cent.

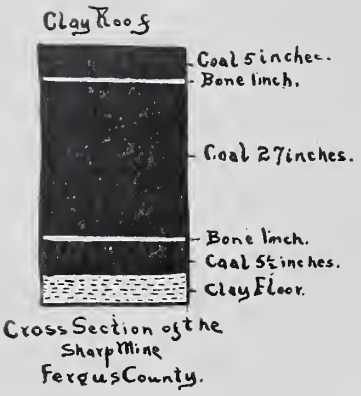
The Spring Creek Coal company mine is located a little more than a mile from Lewistown, on Spring creek, being connected by a railway spur with the railroad at Lewistown. The seam developed is four feet in thickness, three feet of which is fine quality. The property is being operated under lease by Mr.

William Close, who is producing about 80 tons per day, the mine being equipped with compressor and machine. The seam lies at a dip of ten to twelve degrees and the main entry is put down several hundred feet on this dip and a sump made for water catchment. The output of the mine is marketed to the Montana railway and to the towns along that line. The output for the ten months of 1906 was 9,640 short tons, working 266 days with 21 inside and 6 outside men.

Cross Section Spring Creek Coal Co's.,
Seam near Lewistown,
Fergus County.

The Hamilton mine is located about eight miles north of Lewistown and is operated by the Hamilton Coal company. The developed seam lies with a dip of from four to six degrees and is four and a half feet in thickness. The output of the mine is marketed in Lewistown.

Aside from these properties, there are many prospects being developed, among which are the Gold Reef Coal Mining company near Gilt Edge, the Montana Coal company, eight miles northeast of Lewistown, the Sharp Coal mines, eight miles southeast of Lewistown on the north fork of McDonald creek, the Pieper Coal company, near Lewistown, Lewis & Sealey, near Gilt Edge, George Shearson, near Gilt Edge, the Black Diamond Coal company on McDonald creek, the Mace mines, under lease to Mr. Thos. Phillips, near Maiden, the Fergus Land & Live Stock company and Mr. Sam Schultz, near Utica, the McDonald Coal company, on Coal creek. The evaporation of the coals in



Cross Section of the Sharp Mine Fergus County.

the neighborhood of Gilt Edge are as follows: Water evaporated per pound of coal, 7.3 pounds (moisture 5.8 per cent), equivalent water evaporated at 212 F., per pound of dry coal, 7.67 pounds. In the Judith mountains the Cliff and Warm Springs mines are operated to supply the local country demand.

FLATHEAD COUNTY.

Flathead county has a large coal area, and the fields have an excellent quality of coal, but there is little development on account of the remoteness from shipping facilities of the greater part of the measures. Coal has been found on the North Fork, Middle Fork and South Fork of the Flathead river, and the only real development accomplished has been in the North Fork area, where the Flathead Coal and Iron company has operated, showing eight seams on their property ranging from eighteen inches to twelve feet in thickness, the veins having a dip of 45 degrees. It is reported that four of the seams prospected gave an aggregate width of 30 feet. The upper seams are lignite and the lower seams are lignitic bituminous coal. The property is thirty miles from rail and cannot be worked owing to the lack of shipping facilities. The following is an analysis of this coal:

Moisture	1.270 per cent.
Volatile combustible matter	52.077 per cent.
Fixed carbon	35.415 per cent.
Ash	11.237 per cent.
Total	99.99 per cent.

The character and quality of the coal in the other areas is the same as in the North Fork, but there has been no development other than the smallest prospecting. There are no coal mines in the county.

GALLATIN COUNTY.

The coal measures of Gallatin county, so far as developed, lie in the extreme central eastern and northern parts of the county, what is termed the Gallatin field being in the southern part, the

FACE OF TUNNEL, GEBO MINE, LEWISTOWN, MONTANA.

TIPPLE AND ENGINE HOUSE, SPRING CREEK COAL COMPANY OR GEBO MINE, LEWISTOWN, MONTANA.

FACE OF TUNNEL, HAMILTON MINE, 9 MILES EAST OF LEWISTOWN.

PLANT AT STORRS, MONT.

FACE OF MINE TUNNEL AT STORRS, MONTANA.

COKE OVENS AT STORRS, MONTANA.

GENERAL VIEW OF STORRS, MONTANA, SHOWING 100 UNFINISHED COKE OVENS.

PLANT AT MOUNTAINSIDE, MONTANA.

PLANT AT CHESTNUT, MONTANA.

Trail creek in the eastern central and the Yellowstone in the northeastern part of the county.

In point of location and working, the mines at Chestnut are the oldest in the state, the ground having been located and opened in 1867, and the product was in some instances teamed great distances to parts of the state where there was no wood for fuel and where the existence of coal was not then thought of.

Cross Section of Coal bed at Storrs Gallatin County.

The property opened and worked in that early day is now owned and operated by the Northern Pacific railway, under its subsidiary company, the Northwestern Improvement company. The developed seam varies from five to nineteen feet in thickness, but is somewhat interstratified with bone which, in handling, is removed in the washer. The surface and the mine is equipped in the most thorough modern way, every convenience for the quick and economical mining and handling of the coal being provided. The output of the mine for 1905 was 124,380 short tons, the mine operating 313 days, employing 34 outside and 127 inside men, and during the ten month period of this year, working 258 days with 95 inside and 30 outside men, produced 86,175 short tons.

About four miles south of the main line of the Northern Pacific, on the Mountain House branch, the Washoe Coal & Coke company have been doing prospecting during the year. The coal of this property is of the coking variety. The property, both in the mine and on the surface, is equipped in the most modern way, including a large Luhrig washer, electric lighting and power plant and 200 coke ovens. The prospecting having been successful, it is anticipated that the mines will produce largely during the next year.

The following is an analysis of the Chestnut coal:

Moisture	8.64 per cent.
Volatile combustible matter	23.10 per cent.
Fixed carbon	50.18 per cent.
Ash	18.08 per cent.

The coal seams of Gallatin county belong to the Laramie formation.

GRANITE COUNTY.

Granite county is located on the western side of the main range and is skirted on its northern border by the main line of the Northern Pacific railway, and has a spur on the line extended south from Drummond to the central part of the county at Philipsburg, a distance of about 25 miles. Lignite deposits have been opened between Stone and Drummond, on both sides of Flint creek, but have not been extensively prospected. There are many prospects in the neighborhood of New Chicago, Hall, Philipsburg and Drummond, considerable work being done in some places, but there has not been any considerable extraction of coal.

About three miles from Drummond, Mr. Isaac Parry has developed a seam lying at a dip of 30 degrees, which is five and one-half feet in thickneses, and there is another seam eight feet in thickness lying a few feet below this, being separated by a layer of sandstone. As any considerable vertical depth brings in water, it is planned to tap this vein with a crosscut tunnel, at a depth of 500 feet, which will afford both drainage and gravity working. The workings are equipped with a steam hoist. The product is a good quality of lignite. The analysis of this coal is as follows:

Moisture	12.06 per cent.
Volatile combustible matter	40.24 per cent.
Fixed carbon	37.20 per cent.
Ash	10.50 per cent.

Analyses of other samples of the field give approximately the same results.

JEFFERSON COUNTY.

Though there are Laramie and Neocene deposits in Jefferson county, so far as discovered these seem to be barren, and the only coal known to exist in the county is at Sappington, where there is a small seam of Devonian coal that is not of any commercial value.

LEWIS AND CLARK COUNTY.

Though there are no coal mines within the county of Lewis and Clark, the county has a large area that is underlain with bituminous coal, the measure being an extension of the Cascade county field, and runs from the extreme northern end of the county in a southeasterly direction to a point south of the central part of the county, and this part of the field offers the finest of opportunities for prospecting and development of coal. The character and quality of the coal is the same as that of the developed parts of the field in Cascade county.

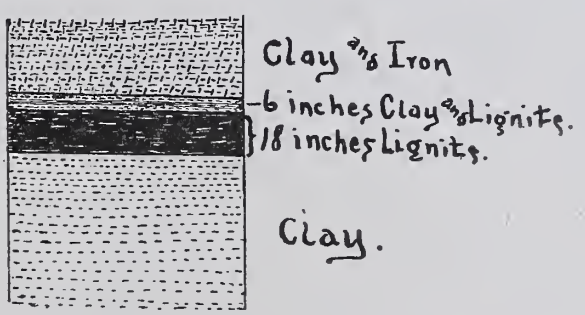
The only considerable opening of the measure in this county is in the neighborhood of Augusta, where there are several small mines producing coal for the consumption of the surrounding ranch country. An analysis of this coal is as follows:

Moisture	1.763 per cent.
Volatile combustible matter...	40.770 per cent.
Fixed carbon	45.914 per cent.
Ash	11.552 per cent.

The coal is free from sulphur and is a good gas coal. The veins are all of good thickness. All of the coal area of the county is too remote at this time to allow profitable working, but the field, in any part, can be easily reached by short spurs from the Montana Central railway, and will unquestionably be developed in the near future.

MADISON COUNTY.

Madison county, though one of the most mountainous of the state, has a considerable area of coal lands. South of Virginia



Cross Section, Lignite Seam on Bean Creek, Madison County.

City there is a coal measure that underlies the Ruby valley and is in the Laramie formation. A number of properties have been secured in this district, but as yet there has not been sufficient development other than to show a good thickness of seam and quality of coal. Coal is also found on Warm Springs creek and in the basin of Jackass creek, in this latter district, although the seam is small, the coal is of a semi-anthracite, the analysis being as follows:

Moisture	5.282 per cent.
Volatile combustible matter	5.634 per cent.
Fixed carbon	84,671 per cent.
Ash	4.412 per cent.

Both east and west of Monida have been found several outcroppings of lignitic and semi-bituminous coal, the seams lying high up on the mountains, and have not been prospected to any extent. There is also a thin seam on Bean creek, fifteen miles east of Monida, that is producing for the local custom. A coking coal found near Monida, but not developed, gives the following analysis:

Moisture	25 to 6 per cent.
Volatile combustible matter	45 and less.
Fixed carbon	44 to 45 per cent.
Ash	6.4 and less.

MEAGHER COUNTY.

There is quite a large area in the south central and eastern part of Meagher county that is underlain with a western arm of the central Carbon county measure, and what is termed the Yellowstone field. The coal is a good grade of semi-bituminous character. There are several seams that occur about twenty miles southeast of White Sulphur Springs, at the foot of Castle mountain, and one of these, near the forks of Checkerboard creek, has been worked for a good many years, producing coal for local consumption. A cropping appearing in the benches of Warm Springs creek has been prospected in several places, but so far the coal is interstratified with shales and is not of commercial value. South of Castle there are several seams of good thickness and quality of coal. The best demonstrated coal district of the county is located on Sixteen Mile creek, where the

MINE OPENING ON BEAN CREEK, 15 MILES FROM MONIDA, MONTANA.

seam outcrops for some distance and dips into the hills at about 35 degrees. There has been some development of the seam accomplished with an incline and drifting, proving it to be over seven and a half feet in thickness, with five feet of clean coal. Following is the analysis of the coal:

Moisture	1.217 per cent.
Volatile combustible matter	46.998 per cent.
Fixed carbon	43.445 per cent.
Ash	7.784 per cent.
Sulphur	0.565 per cent.

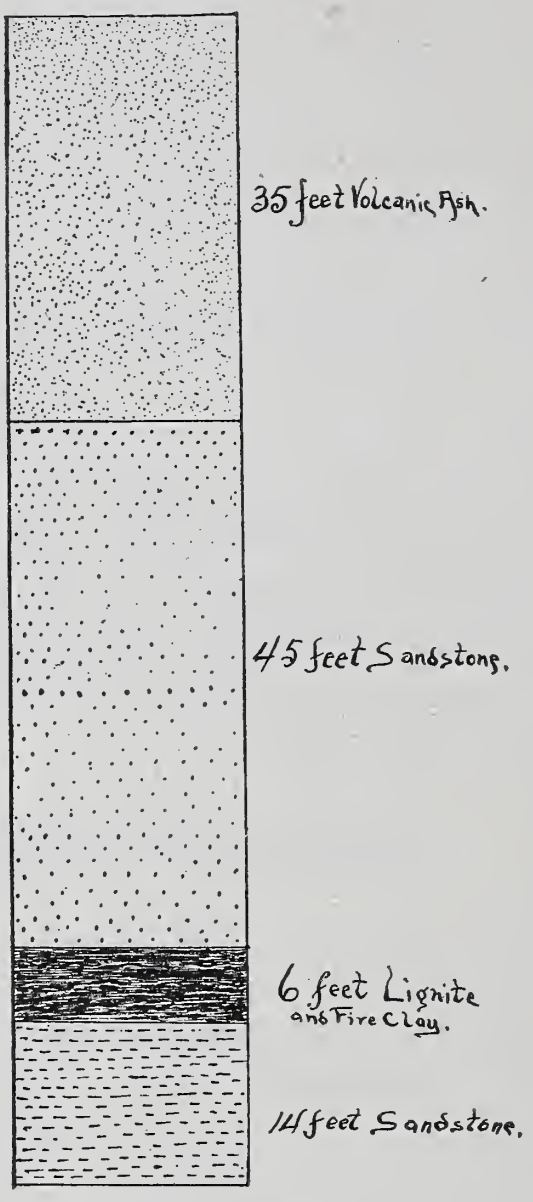
Coal seams have also been opened up at the head of Smith river, and at the head of Cottonwood creek.

The coal measures mentioned are all remote from shipping facilities, except the western part of the central measure, which is crossed by the Montana railway, and this fact has prevented their extensive exploitation.

MISSOULA COUNTY.

So far as ascertained, Missoula county does not contain a great deal of coal, and such seams as have been discovered and prospected, while, with development they may attain to a considerable output that will be taken up by the local demand, it is not likely that any of them will become shippers, the more extensive working being prohibited by both the quality of the coal and the dimensions of the seam and field. There are several outcrops near Missoula that have been prospected considerably and worked in a limited way at different times, but are not in operation this season. The best seams discovered are those belonging to Messrs. Ritchie & Cobban. Both of those penetrate the mountain, the one highest up, with development, proving to be four feet thick and the other, several hundred feet lower down, proving to be siv feet in thickness. These seams could be made to produce a large amount of coal for the local market. The following is an analysis of the Missoula lignite:

Moisture	9.31 per cent.
Volatile combustible matter	41.17 per cent.
Fixed carbon	39.60 per cent.
Ash	9.92 per cent.



Section of Well near Missoula, Missoula County

There are also outcrops of lignite in the neighborhood of Frenchtown. The Missoula coal measures belong to the Neocene formation.

PARK COUNTY.

Park county has four coal areas. There is one measure crossing the county from east to west, about the center, and in the northern part of the county there is a long extension south of an arm of the Yellowstone field, while at the extreme southern part of the county there are two separated eliptical fields. The southern seams are classed as belonging to the Cinnabar field, the

central as to the Bozeman, and the northern as to the Yellowstone field.

The Montana Coal & Coke company operates an extensive and modernly equipped mining and coking property at Aldridge, which is situated a couple of miles from the town of Electric, which is located in the southwestern part of the county and near the north line of the Yellowstone National Park. The main workings are in one of the four workable seams of the field. The surface working plant is located at Electric and the mine at Aldridge, the former being located on the Park branch of the Northern Pacific railway. The mine and the surface plant is connected with a tram that runs to the mine on a grade of nearly 45 per cent. The mine is developed by four entry ways. The plant embraces four 150 horsepower boilers, two 500-volt generators, and 800-light dynamo, electric motor, tipples, 250 coke ovens, etc. The output of the mine for 1905, working 125 days, was 39,867 short tons of coal and 13,442 tons of coke, 100 men working inside the mine and 14 men outside. For the ten months of this year, working 250 days during that period, with 121 men inside and 43 outside men, the output was 91,257 short tons. The analysis of the coking coal is as follows:

Cross Section of the Montana Coal & Coke Co. Mine Park County

Moisture	00.97 per cent.
Volatile combustible matter	30.60 per cent.
Fixed carbon	58.00 per cent.
Ash	10.43 per cent.

The semi-anthracite variety runs from 75 to 93 per cent in fixed carbon.

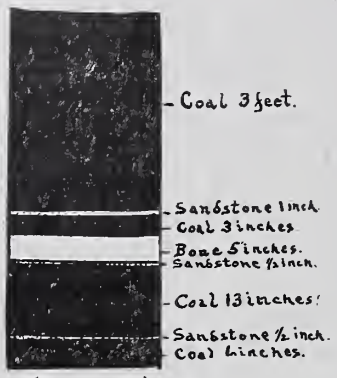
There are two small mines on the opposite side of the river from Electric, which produce good coal, but the seams, while being workable, are not thick.

The property at Cokedale, which was operated for some years, has been closed down and abandoned, temporarily at least

During 1905 Park county produced 101,139 tons of coal, and for the ten months of the present year produced 109,159 tons.

From Chestnut there is a spur of the Northern Pacific railway running southeast to Mountain House, where there are several

coal mines and prospects. The Mountain House, known locally as the Hoffman mine, is being operated under lease by Messrs. Evans & Anderson. The mine is opened by a slope of 300 feet driven on the vein, which has a dip of 45 degrees. The property is equipped with a steam hoist, tipple, screens, etc. During the year 1905 the output of the mine was 2,610 short tons, the mine having worked 100 days with 4 outside men and 15 inside men. The output for the ten months of 1906 was 12,022 short tons, having worked 248 days, with 26 inside and 4 outside men. The coal is of good quality and goes largely to the domestic market.



Cross Section of the Mountain House Coal Co. Mine Park County

The Kuntz mine, which is owned by Mr. Kuntz, a banker of Bozeman, is located about a mile from the Mountain House mine, down Trail creek, and has been additionally developed during the past summer, preparatory to active operation, by the driving of a new entry way on the vein. The mine is equipped with a steam hoist, tipple, screens, ventilation fans, etc. This property will undoubtedly be a producer the coming year. Production for 1905, 300; 1906, 5,580 tons.

The Maxey mine is located still further down Trail creek, about one and a half miles, and is being developed and placed in a position to produce steadily and largely. The mine has been equipped with a steam hoist, tipple, and all conveniences for the economical handling of the production.

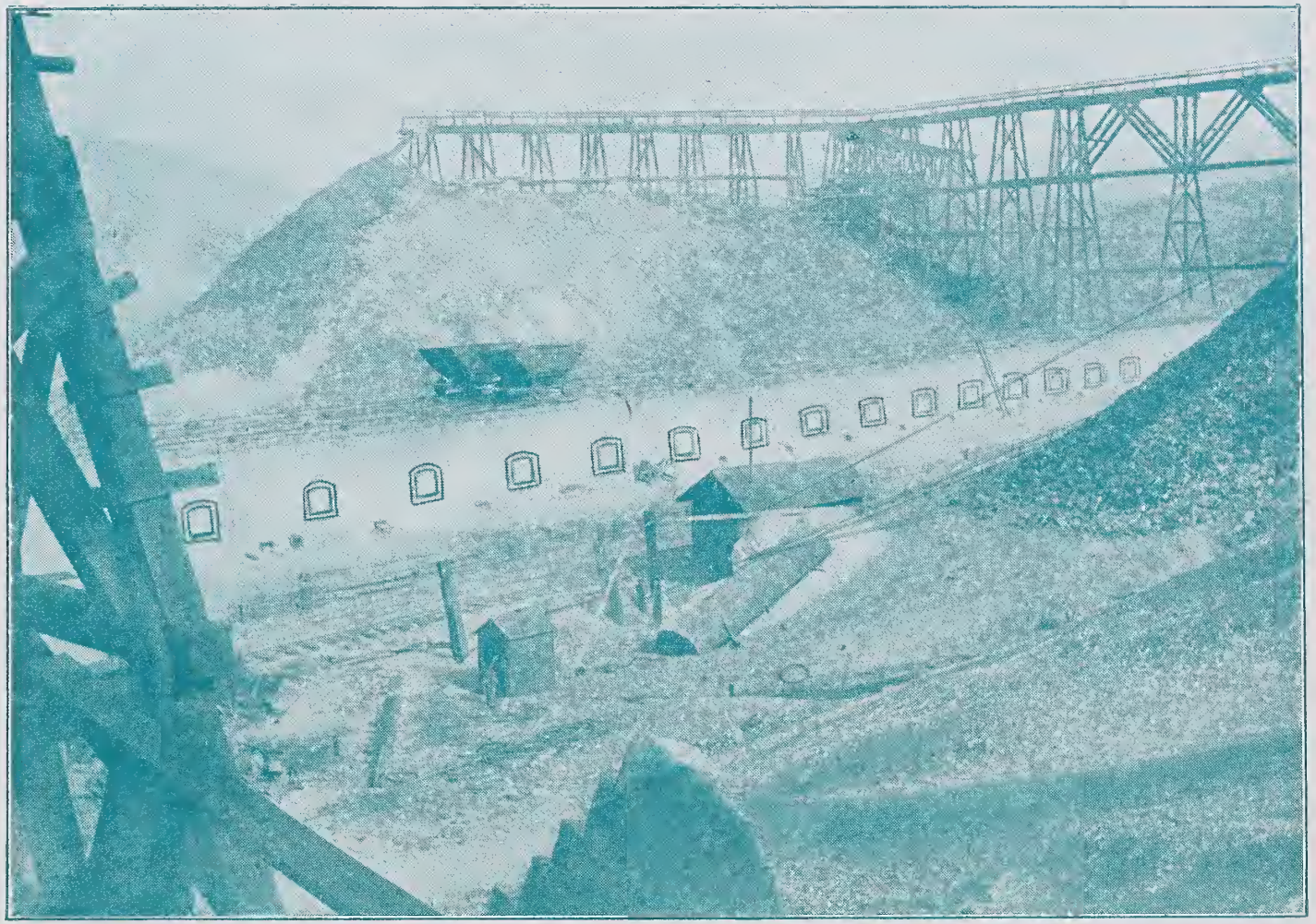
POWELL COUNTY.

Powell county is one of the mountainous counties of the state. Coal has been discovered in the vicinity of Avon and near Ovando, and there is said to be coal in the Dog creek mountains south of Avon, but there has not been any development to demonstrate the thickness of the seams or extent of the areas. Some years ago there was a coal property just west of the summit of the main range, at Mullan, which produced a good quality of coal, but has not been worked for several years. The deposits are in the Neocene formation and are lignitic in character.

TUNNEL AT NELSON BROS'. MINE, SANDCOULEE MONTANA.

A. C. M. PLANT AT BELT, MONTANA

GENERAL VIEW OF A. C. M. PLANT AT BELT, MONTANA, FROM SOUTH



COKE OVENS AT BELT, MONTANA.

GENERAL VIEW OF PLANT AT BELT, MONTANA. FROM NORTH.

RAVALLI COUNTY.

Ravalli county comprises the southwest section of the state, and has a heavy range of mountains on both its western and eastern sides, the Bitter Root valley lying between. There are three coal measures within its borders, one in the northeastern part of the county, one a short distance south of the center of the county, at Darby, the terminus of the Bitter Root branch of the Northern Pacific railway, and one in the extreme southern part of the county. There has been considerable development and some working, for the use of the local market, of the southern bed, which has proved to be 13 feet in thickness and of excellent lignite character, the following being an analysis:

Cross Section of Coal Seam. near Darby Ravalli County

Moisture	16.275 per cent.
Vol. comb. matter	31.321 per cent.
Fixed carbon	36.910 per cent.
Ash	15.493 per cent.

The measure in the vicinity of Darby has two seams, one five and the other eight feet in thickness. These seams have been explored by constructing an entryway into each a distance of about 100 feet. The following is an anaylsis of this coal:

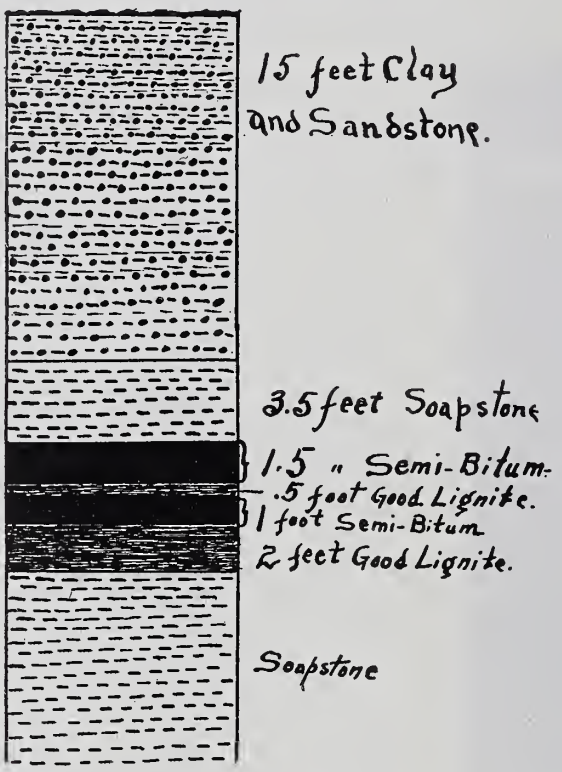
Moisture	17.680 per cent.
Vol. comb. matter	19.000 per cent.
Fixed carbon	38.803 per cent.
Ash	24.226 per cent.

The high ash is accounted for by the fact that the sample was mine run, not being cleaned. There are clay nodules in the coal seams, but these can easily be removed and do not materially interfere with the quality of the coal.

The coal measure on Hughes creek is said to run from five to twenty-five feet in thickness, and an excellent lignite. The coal beds are in the Neocene formation, and their area at this time is only a surmise.

ROSEBUD COUNTY.

It is calculated that the entire eastern portion of Rosebud is underlain with an extension of the lignite field that covers Custer county, but the area has not been prospected except in the vicinity of Forsyth, the county seat, which is located on the line



Cross Section of Boomer and Patterson (Marceys) Mine
Seven Miles South of Forsyth,
Rosebud County.

of the Northern Pacific railway. The mine is located about seven miles from town, on Smith creek, and has been producing in a small way for some years, supplying the market of the country and town of Forsyth. The seam is five feet thick and a good quality of semi-bituminous coal. Following is the analysis of the coal:

Moisture	9.516 per cent.
Volatile combustible matter	38.212 per cent.
Fixed carbon	44.724 per cent.
Ash	7.547 per cent.

SWEET GRASS COUNTY.

The northern part of Sweet Grass county is underlain with an extension of the Yellowstone coal field and has an extension in the central part of the Bozeman field, which finds its terminus about the center of the county. There is another coal area in the extreme southern part of the county. The fields are wholly unprospected, the only opening of note that has been made being near McLeod, on the Boulder river and about 20 miles from Big Timber. The coal is semi-bituminous and of the coking variety. There seems no question but that in the future there will be considerable coal produced from the several measures of the county.

TETON COUNTY.

The Great Falls coal field, passing through the northern part of Lewis and Clark county, extends north through the western and entire length of Teton county to the International boundary line. The field has been opened to some extent, and has produced for local consumption, in a number of places. The largest property is located on Birch creek, and this produces in the neighborhood of 1,000 tons per annum for the trade of the immediate vicinity. The seam, where developed, is not thick, running as thin as 22 inches and lying about 60 feet beneath the surface. The analysis of this coal is as follows:

Moisture	9.077 per cent
Volatile combustible matter	37.866 per cent
Fixed carbon	41.928 per cent
Ash	17.158 per cent

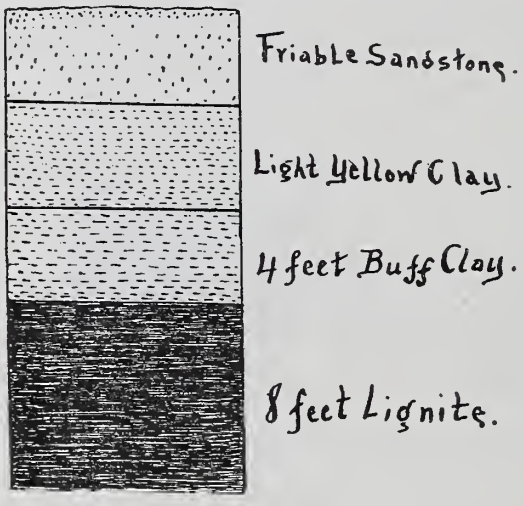
About 20 miles southwest of Choteau, on the north fork of Sun river, a coal seam about 50 inches in thickness and containing a 6-inch band of blacksmith coal has been opened and operated to the extent of the requirements of the surrounding agricultural community.

Prospecting has also opened out coal at Cut Bank, on the south fork of the Milk river and at several places on the Milk river bench and at one point on the Lower St. Mary's lake, but none of these places have been worked or even prospected sufficiently to assure the permanent thickness of the seams. Dur-

ing the next few years there should be a very considerable development of the field, especially in those portions of the field that are near either of the Great Northern lines.

VALLEY COUNTY.

So far as discovered the coal area of Valley county lies in an extension of the Custer county field that passes through Dawson county and extending over the southeastern part of Valley county. The only prospecting or development has been



Cross Section Lignite Seam 3 miles
West of Culbertson
Valley County.

accomplished at several points in and around Culbertson. The best seam is opened about 12 miles east of Culbertson, and there is another opening about six miles east on Stafford creek, another about 8 miles and another about three miles from Culbertson, the seams opened running from 2 to 12 feet in thickness. In the Poplar river district northwest of Culbertson, the seam is 22 feet thick, and across the Missouri south of Culbertson, it runs from 10 to 20 feet in thickness. The agricultural country and the town of Culbertson and other towns along the railway in the coal area secure their domestic fuel entirely from these openings.

YELLOWSTONE COUNTY.

That part of Yellowstone county extending from a short distance west of Billings, is underlain with coal, the measure extending north from Carbon county, but as yet, largely owing to the remoteness of the greater part of the area from railway facilities and the proximity of the local market to the coal mines of Carbon county, there has been little development or prospecting. An analysis of the coal is as follows:

Moisture	7.84 per cent
Volatile combustible matter	42.71 per cent
Fixed carbon	42.65 per cent
Ash	6.80 per cent

OUTPUT OF COAL AND COKE FOR THE YEAR 1905.

The Amount of Coal and Coke Produced, by Whom, the Number of Days Worked and the Number of Men Employed.

Name of Company.	Address.	Superintendent.	Mine Foreman	Output short Tons Produced	Number days Mine worked	Number of inside men	Number of outside men
Anaconda Copper Mng. Co., Coal Dep't.	Belt	Kinney, J. J.	Fisher, Charles	265,744	263	325	75
Lewis Coal Mine	Belt	Colone, Frank		3,000	200	6	6
Orr Brothers Mines	Belt	Orr, William		900	180	2	
Millard Mines	Belt	Millard, H. W.		500	250	2	
Richardson Coal Mine	Armington	Richardson, Matt		500	160	2	
Cottonwood Coal Company	Stockett	Pearson, James	Pearson John	465,432	230	367	142
Nelson Coal Company	Sand Coulee	Pearce, John		93,245	203	80	10
The Gerber Mines	Sand Coulee	Gerber, Edward	Rothwell, John	13,229	240	11	5
Northwestern Improvement Company	Red Lodge	Pettigrew, Robert	Haggerty, William	590,035	302	480	120
Bridger Coal Company	Bridger	Dale, Samuel	Dale, Sam	39,417	250	54	16
Cokedale Coal Company	Cokedale	Good, Thomas	Anderson, J. A. Sederholm, Chas				
Carbon Mines	Fromberg	McCarthy, J. C.	Killorn, Geo. S.	8,000	220	10	2
Gebo Coal Company	Gebo	Lloyd, D. J.	Kilpatrick, Robert	7,625	146	30	20
International Coal Company	Bear Creek	Rosetti, H.		1,175	40	5	
Montana Fuel and Iron Company	Joliet	Parker, Carman		615	205	1	1
Joliet Coal & Fuel Company	Joliet	Bergin, John		500	30	5	1
Northwestern Improv. Co., Coal Dep't.	Mountainside	Forsyth, Geo.	Bailey, John	124,380	313	127	34
Montana Coal & Coke Company	Aldridge	Magraw, R. M.	Williams, Charles	*39,867	125	100	14
The Kuntz Mines	Chimney Rock	Strapage, John		3,000	150	10	3
Mountainhouse Mines	Trail Creek	Anderson, J. W.	Evans, T J.	2,610	100	15	4
Washoe Copper Co., Coal Dep't.	Storrs	Griffin, Geo. N.		500	**	10	6
Ayars Mine	Havre	Ayars, G. J.	Fritz, H. H.	2,000	300	3	1
Hadalin Coal Mine	Havre	Hadalin, Adam		1,400	313		
Alcott's Coal Mines	Havre	Alcott, J. R.		1,000	300	2	

OUTPUT OF COAL AND COKE FOR THE YEAR 1905—Continued.

Name of Company	Address	Superintendent	Mine Foreman	Output short Tons Produced	Number days Mine worked	Number of inside men	Number of outside men
Lewis & Seeley Mine	Gilt Edge			4,500	270	6	.....
Black Diamond Coal Company	Lewistown	Dougherty, Chas.		1,500	200	3	.....
Montana Coal Company	Lewistown	Holman, D. H.		700	100	4	.....
Mace Mines	Maiden	Phillips, Thos.		1,200	240	3	.....
The Brugger & Nugent Mines	Culbertson			500	200	2	.....
The Harrison Mine	Spring Creek	Harrison, Henry		500	100	2	.....
The Schultz Mine	Utica	Schultz, Samuel		1,015	240	2	.....
Spring Creek Coal Company	Lewistown	Close, W. H.		12,000	300	25	.....
Miscellaneous Mines				1,520	.....	.....	.....
Toatls				1,743,771	6,482	1,775	514

* Coke: Cokedale Coke Co., 18,039 tons; Montana Coal & Coke Co., 13,442 tons; Total coke 31,481 tons.

** Prospecting.

OUTPUT OF COAL AND COKE FOR THE TEN MONTHS OF 1906, ENDING OCTOBER 31st.

The Amount of Coal and Coke Produced, by Whom, the Number of Days Worked and the Number of Men Employed.

Name of Company.	Address.	Superintendent.	Mine Foreman	Output short Tons Produced.....	Number of days mine worked.....	Number of inside men...	Number of outside men..
Anaconda Copper Mining Co., Coal Dept..	Belt	Kinney, J. J.	Fisher, Charles ..	258,547	244	296	68
The Lewis Mines	Belt	Schmauch, Fred ...	.....	3,000	200	5	1
The Orr Mine	Belt	Orr, Samuel	Orr, William	2,000	200	3	2
Millard Mine	Belt	Millard H. W.	.....	900	300	2	1
The Richardson Mine	Armington	Richardson, Matt ..	.....	800	200	2	1
Cottonwood Coal Co.	Stockett	Pearson, James	Pearson, John ...	462,040	212	356	135
Nelson Coal Company	Sand Coulee	Pierce, J. N.	.....	78,000	290	60	10
The Gerber Mines	Sand Coulee	Rothwell, John	.....	32,478	213	29	8
Stainsby-Latham Coal Co.	Sand Coulee	Stainsby, William .	.....	608	180	2	1
Northwestern Improvement Co.	Red Lodge	Pettigrew, Robert ..	Haggerty, Wm ..	356,573	209	500	100
Bridger Coal & Iprov Co.	Bridger	Good, Thomas	Sederholm, Chas	35,000	220	80	25
Carbon Mines (J. C. McCarthy)	Fromberg	Killorn & Weber,	(leasers)	9,000	250	12	3
Gebo Coal Company	Gebo	Griffith, H. H.	Kirby, John R...	19,384	100	47	12
Joliet Coal & Fuel ompany	Joliet	Bergin, John	.....	9,000	.....	.....	.....
Northwestern Improvement Co.	Chestnut	Forsyth, George.....	Walker, John C.	86,175	258	95	30
Montana Coal & Coke Company	Electric	Magraw, Robert M.	Williams, Chas...	91,257	250	121	43
Mountain House Coal Company	Chimney Rock	Evans, T. J.	.....	12,022	248	26	4
Trail Creek Coal & Land Company	Chimney Rock	McLaughlin, J. E. .	Thompson, Robt.	5,580	130	10	3
Washoe Copper Co., Coal Dep't	Storrs	Griffin, G. N.	.....	*	.....	9	7
Bear Creek Coal ompany	Bear Creek	Gallagher, P. M. ...	Williams, Thos .	2,989	60	75	8
Montana Coal & Iron Co.	Bear Creek	Russell, George	.....	2,000	50	50	10

OUTPUT OF COAL AND COKE FOR THE TEN MONTHS OF 1906 ENDING OCTOBER 31ST—Continued.

Name of Company	Address	Superintendent	Mine Foreman	Output short Tons Produced	Number of days mine worked	Number of inside men	Number of outside men
Montana Coal Company	Lewistown	Holman, A. D.		2,000	200	5	.....
Spring Creek Coal Company	Lewistown	Close, W. H.		9,640	266	21	6
The Sharp Mine	Lewistown	Sharp & Tayer		500	200	2	1
The Mace Mine	Maiden	Philips, Thomas		1,500	125	4	1
The Schultz Mine	Sage Creek	Schultz, Sam		900	140	5	1
Big Sandy Coal Mines	Big Sandy	Mack, C. C.		1,000	300	4	2
The Kerr Mine	Chinook	Kerr, William		600	150	2	1
The Havre Fuel Company	Havre	Bossuot, Frank F.		3,000	300	8	3
Miscellaneous prospects				15,707	.....	.....	.....
Totals				1,502,200	5,495	1,831	487

Note—Montana Coal & Coke Co., coke,32,666 tons.

Mines producing less than 500 tons are not quoted in the above table, and the miscellaneous output is largely from Custer County, where there are a great number of neighborhood prospects, and from Meagher County, and from J. L. Harmon, Lewistown; Wm. Maxey, Chimney Rock; Bruger & Nugent, Culbertson; J. R. Alcott, Havre; Adam Hadalin, Havre; J. J. Lewis, Gilt Edge; F. E. Peiper, Lewistown, etc.

** The output of coal is taken for the ten months of the year ending the 31st of October. The output for the calendar year will be fully two million short tons, these months giving the largest output of the year. Hereafter the coal statistics will commence and close the year on the 31st day of October.

THE COAL PRODUCTION OF THE UNITED STATES.

Mr. E. W. Parker statistician of the United States Geological Survey, says the production of coal in 1905 amounted to 392,919,341 short tons, valued at the mines at $476,756,963, surpassing in both quantity and value all previous records in the history of the country. Compared with 1904, when the production was 351,816,398 tons, valued at $444,371,021, the output in 1905 exhibits an increase of 41,102,943 tons, or 11.7 per cent in quantity, and of $32,385,942, or 7.3 per cent in value. Prior to 1905 the maximum output of coal was reported in 1903, when it amounted to 357,356,416 tons, valued at $503,742,381, compared with which the record for 1905 shows an increase of 35,562,925 tons, $26,967,418. The high value recorded in 1903 was due to the somewhat abnormal inflation of prices, caused by the shortage of fuel supplies, which resulted from the strike in the anthracite region of Pennsylvania in the preceding year. The lower values in 1904 as compared with 1903 were simply a return to normal conditions, but the decline in 1905 was the result of a production in excess of market requirements, unusually large as they were.

Of the total production in 1905, 69,339,152 long tons (equivalent to 77,659,850 short tons) were Pennsylvania anthracite, with a value at the mines of $141,879,000. The total production of bituminous coal and lignite was 315,259,491 short tons, valued at $334,877,963. The production of anthracite coal in 1905 was 4,020,662 long tons (4,503,151 short tons) more than 1904, while the increase in the production of bituminous coal and lignite was 36,599,882 short tons. A portion of these increases was due to the efforts of operating companies to provide a supply of fuel in anticipation of a suspension of mining in April, 1906, when the wage-scale agreements in the organized coal producing states and the award of the Strike Commission in the anthracite region of Pennsylvania would terminate.

It is a fact worthy of note that the total increase in the production of coal in the United States in 1905 over 1904 was larger than the production of France in 1904, or of the output of any other foreign country except Great Britain, Germany, and Austria-Hungary, and was almost equal to that of the last mentioned country. The total production of the United States last year was nearly 50 per cent greater than Great Britain,

which until 1899 was the leading coal mining country of the world, and was more than double that of Germany. Another interesting fact is that in each decade the output has been practically doubled. Up to the close of 1865 the total production was 284,890,055 tons. In the decade from 1866 to 1875, inclusive, the production was 419,425,104 tons, making the total output up to the close of 1875, 704,315,159 tons. In the following decade, from 1876 to 1885, the production amounted to 847,760,319 tons, something more than double the total to the beginning of that decade. At the close of 1885 the total production was 1,552,075,478 tons, and the production for the 10 years ending with 1895 was 1,586,098,641 tons, and to the close of 1895, 3,138,174,119 tons. In the decade ending with 1905 the total production was 2,832,599,452 tons, and the grand total from the beginning of coal mining amounted to 5,970,773,571 short tons.

Of the total bituminous coal produced in 1905, 103,396,452 tons were mined by machines, as compared with 78,606,997 tons in 1904. Mining machines in use increased from 7,663 in 1904 to 9,184 in 1905.

The total number of men and boys employed last year was 626,174, against 593,693 in 1904. Of the total for 1905, 165,406 were employed in the anthracite mines of Pennsylvania, and 460,768 in bituminous coal mines. The average number of days worked by the anthracite miners was 215, and by the bituminous miners 211 days.

The coal mining industry in 1905 was comparatively free from labor troubles,the only important exception being in Illinois, where a large number of mines were shut down as a result of a disagreement between the miners and operators over the shotfirers' law. This law, which was obnoxious to the miners employed additional men for firing the shot placed by the miners, and incurred thereby an extra expense, which the operators in a number of cases refused to pay, contending that it was a violation of the agreement and that the expenses of mining coal were not to be increased by any action of the miners. A number of strikes resulted, and a serious disturbance of the peaceful relations which had existed in Illinois for several years was threatened. The matter was submitted by arbitrament to Judge George Gray, who had been chairman of the Anthracite Coal Strike Commission. Judge Gray decided that the expenses should be equally divided between the miners

and the operators. Work was resumed when the matter was submitted to arbitration, and the rest of the year was comparatively free from strike suspensions. The number of men on strike in Illinois during the year was 15,289, or 47 per cent of the total idle on account of strikes in all the bituminous mines of the United States.

The larger part of the increased production in 1905 was due to the great activity in the iron industry as is shown by the fact that the amount of coal made into coke increased from 31,278,537 short tons in 1904 to 42,412,328 tons in 1905. The table below exhibits the production and value in the different states in 1904 and 1905.

TABLE OF COAL PRODUCTION AND VALUES 1904-1905.

	1904		1905	
	Quantity short tons	Value	Quantity short tons	Value
Alabama	11,262,046	$13,480,111	11,866,069	$14,387,721
Arkansas	2,009,451	3,102,660	1,934,673	2,880,738
California and Alaska	79,582	377,306	80,824	395,975
Colorado	6,658,355	8,751,821	8,826,429	10,810,978
Georgia and North Carolina	390,191	476,996	353,548	456,184
*Idaho	3,480	13,730	5,882	17,846
Illinois	36,475,060	39,941,993	38,434,363	40,577,592
Indiana	**10,842,189	**12,004,300	11,895,252	12,492,255
Indian Territory	3,046,539	5,532,066	2,924,427	5,145,358
Iowa	6,519,933	10,504,406	6,798,609	10,586,381
Kansas	6,333,307	9,640,771	6,423,979	9,350,542
Kentucky	**7,576,482	**7,868,192	8,432,523	8,385,232
Maryland	4,813,622	5,729,085	5,108,539	5,831,760
Michigan	1,342,840	2,424,935	1,473,211	2,512,697
Missouri	4,168,308	**6,801,751	3,983,378	6,291,661
Montana	1,358,919	2,194,548	1,643,832	2,823,350
New Mexico	1,452,325	1,904,499	1,649,933	2,190,231
North Dakota	**271,928	**389,052	317,542	424,778
Ohio	**24,400,220	**26,579,738	25,552,950	26,486,740
Oregon	111,540	243,588	109,641	282,495
Pennsylvania:				
Anthracite	73,156,709	138,974,020	77,659,850	141,879,000
Bituminous	**97,938,287	**94,428,219	118,413,637	113,390,507
Tennessee	4,782,211	5,642,393	5,963,396	6,797,550
Texas	1,195,944	1,983,636	1,200,684	1,968,558
Utah	1,493,027	1,943,440	1,332,372	1,793,510
Virginia	**3,410,914	**2,921,911	4,275,271	3,777,325
Washington	3,137,681	5,120,931	2,864,926	5,141,258
West Virginia	**32,406,752	**28,647,014	37,791,580	32,341,790
Wyoming	5,178,556	6,747,909	5,602,021	7,336,951
Total	**351,816,398	**444,371,021	392,919,341	476,756,963

* Includes production of Nevada.

** Corrected figures. In the report for 1904, the total production for the United States for that year was given at 352,310,427 short tons, valued at $444,816,288. In collecting the statistics for 1905 it was found that in several cases where properties had changed hands or the name of the company had been changed the preceding year, the production for the entire year had been reported by both owners. The duplications thus made have been corrrected for this report.

The production given for Montana is somewhat less than the returns secured by this department, and results from the failure of the federal department to secure the product of a number of little properties that are being operated at different points throughout the state.

FATAL AND NON-FATAL ACCIDENTS, THEIR NATURE AND WHERE OCCURRING, FOR THE YEAR 1905.

Date.	Names.	County.	Name of Mine or Company.	Occupation.	Nature of Accident.
Nov. 17	Hada, Victor	Cascade	Nelson Coal Company	Miner	*Head cut by fall of slate and rock from face of room.
Oct. 17	Dyer, Mike	Cascade	Anaconda Copper Mining Co.	Miner	**Killed by fall of coal from face of room.
Mar. 23	Johnson, Charles	Cascade	Anaconda Copper Mining Co.	Miner	*Injured by horse stepping on drill.
Mar. 29	Sciacqua, Faustino	Cascade	Anaconda Copper Mining Co.	Miner	*Injured by accidental explosion of keg of powder.
Mar. 29	Mistead, Robert	Cascade	Anaconda Copper Mining Co.	Miner	*Injured by accidental explosion of keg of powder.
Mar. 19	Balo, Matt	Cascade	Anaconda Copper Mining Co.	Miner	*Injured by fall of coal.
Nov. 6	Maa, Sacri	Cascade	Anaconda Copper Mining Co.	Miner	*Injured by fall of rock
Dec. 10	Horneck, Steve	Cascade	Anaconda Copper Mining Co.	Miner	*Injured by fall of coal.
Dec. 20	Henderson, Rolli	Cascade	Anaconda Copper Mining Co.	Miner	*Caught foot under pipe line, fell and dislocated knee.
May 9	Smith, Mike	Cascade	Cottonwood Coal Co.	Miner	**Killed by fall of slate while loading car.
May 29	Sheppard, Eli	Cascade	Cottonwood Coal Co.	Miner	**Knocked down by car; leg crushed; died after amputation.
June 7	Pistoria, Paul	Cascade	Cottonwood Coal Co.	Miner	**Killed by fall of coal from face.
May 9	Schwartz, Mike	Cascade	Cottonwood Coal Co.	Miner	**Killed by fall of rock from roof.
May 29	Gleason, Thos. G.	Cascade	Cottonwood Coal Co.	Miner	*Knocked from trestle; shoulder and back injured.
Sept. 18	Bakalyar, George	Cascade	Cottonwood Coal Co.	Miner	*Fall of coal, leg broken.
Dec. 3	Michigar, George	Cascade	Cottonwood Coal Co.	Miner	*Fall of coal from roof; back broken and leg bruised.
Nov. 4	Reed, John	Cascade	Cottonwood Coal Co.	Miner	*Fall of rock from roof; small bone of leg broken.
Feb. 13	Puumala, Nestor	Carbon	Northwestern Improvement Co.	Miner	**Killed by fall of rock from roof.
June 15	Foursha, T. J.	Carbon	Northwestern Improvement Co.	Miner	**Killed by fall of rock from roof.
Apr. 7	Anderson, Alex	Carbon	Northwestern Improvement Co.	Miner	*Fall of rock at face of entry; hip dislocated.
Apr. 13	Make, Emil	Carbon	Northwestern Improvement Co.	Miner	*Caught between roof and coal in car; head lacerated.

FATAL AND NON-FATAL ACCIDENTS FOR THE YEAR 1905--Continued.

Date.	Name.	County.	Name of Company	Occupation.	Nature of Accident.
July 22	Lantz, William	Carbon	Northwestern Improvement Co.	Roperider...	*Fell from trip; back injured
Aug. 31	Alholm, Julius	Carbon	Northwestern Improvement Co.	Miner.....	*Fall of coal from face of room; thigh broken.
Nov. 21	Jacobson, Andrew	Carbon	Northwestern Improvement Co.	Miner.....	*Fall of rock at his working face; both legs broken.
Nov. 25	Niemi, Richard	Carbon	Northwestern Improvement Co.	Miner.....	*Fall of coal at face of room; leg broken.
Dec. 5	Harbough, Milton	Fergus	Spring Creek Coal Co.	Miner.....	*Leg broken by fall of rock from roof.
May 31	Baillie, John	Gallatin	Northwestern Improvement Co.	Miner.....	*Kicked by mule; arm broken
Dec. 14	Moses, John	Gallatin	Northwestern Improvement Co.	Miner.....	*Burned by gas explosion.
Dec. 14	Sears, James	Gallatin	Northwestern Improvement Co.	Miner.....	*Burned by gas explosion.
June 19	Davis, Tom	Park	Cokedale Coke Co.	Miner.....	**Killed by fall of rock.
Oct. 8	Pritzel, John	Park	Cokedale Coke Co.	Miner.....	*Thigh broken by fall of rock.

* Non-fatal accidents, 23; ** Fatal accidents, 8.

Note—The above accidents, occurring during 1905, occurred prior to the occupancy of this department by the present inspector, and data for a more complete description of their nature could not be secured.

FATAL AND NON-FATAL ACCIDENTS. THEIR NATURE AND WHERE OCCURING, FOR THE TEN MONTHS OF 1906, ENDING OCT 31.

Date.	Name.	County.	Name of Company.	Occupation.	Nature of Accident.
Mar. 20	Hill, Andrew	Carbon	Northwestern Improvement Co.	Miner	** Killed by fall of coal.
June 7	Flemming, Terry	Carbon	Northwestern Improvement Co.	Motorman	**These eight fatalities were caused by carbon monoxide asphyxiation and poisoning at the Red Lodge disaster of June 7th, 1906, which is fully reported eleswhere in this volume.
June 7	Bracey, J. E.	Carbon	Northwestern Improvement Co.	Road cl'nr	
June 7	Bailey, William	Carbon	Northwestern Improvement Co.	Motorman	
June 7	Carey, Roy	Carbon	Northwestern Improvement Co.	Outside m'n	
June	McFate, Alvin	Carbon	Northwestern Improvement Co.	Trackman	
June 7	Garrich, Mike	Carbon	Northwestern Improvement Co.	Road cl'nr	
June 7	Skelly, Thomas	Carbon	Northwestern Improvement Co.	Timberman	
June 7	Reikka, Matt	Carbon	Northwestern Improvement Co.	Road cl'nr	
June 7	Tarling, William	Carbon	Northwestern Improvement Co.	Track layer	*These seven men were overcome with noxious gases in the Red Lodge Mine, June 7, 1906, but were rescued and resuscitated as reported elsewhere in this volume.
June 7	Bolyard, H. L.	Carbon	Northwestern Improvement Co.	Motorman	
June 7	Wood, Joseph	Carbon	Northwestern Improvement Co.	Ropeman	
June 7	Kintalla, Matt	Carbon	Northwestern Improvement Co.	Timberman	
June 7	Haggerty, William	Carbon	Northwestern Improvement Co.	Foreman	
June 7	"Scotty"	Carbon	Northwestern Improvement Co.	Miner	
June 7	Atherton, Thos.	Carbon	Northwestern Improvement Co.	Outside m'n	
June 7	Davis, Dan	Carbon	Northwestern Improvement Co.	Liquor d'l'r	*And several others prostrated, while trying to perform rescue work.
June 4	Haggerty, William	Carbon	Northwestern Improvement Co.	Foreman	*These six men were overcome with carbon monoxide generated by the fire in room 22, 4th East entry, and were resuscitated.
June 4	White, George	Carbon	Northwestern Improvement Co.	Fireboss	
June 4	Krajacich, Valentine	Carbon	Northwestern Improvement Co.	Miner	
June 4	Pollock, Charles	Carbon	Northwestern Improvement Co.	Miner	
June 4	Smith, Hugh	Carbon	Northwestern Improvement Co.	Miner	
June 4	Mansburger, Baltus	Carbon	Northwestern Improvement Co.	Miner	
Jan. 3	Davis, W. F.	Carbon	Northwestern Improvement Co.	Outside m'n	*Arm broken while trying to put transmission rope on sheave wheel.
Jan. 12	Maga, Louis	Carbon	Northwestern Improvement Co.	Miner	*Leg broken by fall of rock in Room 94, 5 E Entry.
Jan. 12	Thomas, John	Carbon	Northwestern Improvement Co.	Miner	*Slightly bruised by fall of rock in same room.
Apr. 19	Lantis, William	Carbon	Northwestern Improvement Co.	Miner	*Face bruised by fall of roof.
Apr. 19	Aho, Victor K.	Carbon	Northwestern Improvement Co.	Miner	*Foot injured by falling roof.
Aug. 17	Jaakala, John	Carbon	Northwestern Improvement Co.	Miner	*Head and back injured by fall of roof.

FATAL AND NON-FATAL ACCIDENTS FOR THE YEAR 1906—Continued.

Date.	Name.	County.	Name of Company.	Occupation.	Nature of Accident.
Oct. 22	Tarro, James	Carbon	Northwestern Improvement Co.	Miner	*Head cut and foot injured by fall of roof.
	Vincent, Clyde	Carbon	Gebo Coal Company	Miner	*Finger injured in machine.
	Walker, Charles	Carbon	Gebo Coal Company	Miner	Bone of foot crushed in the machine.
	Albertson, Ace	Carbon	Gebo Coal Company	Miner	*Timber fell and bruised thigh
	Kilpatrick, Robert	Carbon	Gebo Coal Company	Miner	*Leg broken by sheave wheel; claimed died of other cause.
	Moree, Peter	Carbon	Gebo Coal Company	Miner	*Foot injured.
	Price, Howell	Carbon	Bridger Coal Company	Rol. greaser	*Struck by slope roller and small bone in leg broken.
	Danielson, Nat.	Fergus	Spring Creek Coal Company	Miner	*Fall of coal.
Oct. 1	Simpson, Thomas	Fergus	Sage Creek Coal Company	Miner	**Killed by fall of rock from roof.
Sept. 28	McDonald, Edward	Gallatin	Northwestern Improvement Co.	Miner	**Killed by fall of coal and roof.
Feb. 2	Dracolich, George	Gallatin	Northwestern Improvement Co.	Miner	*Burned on face and arms by gas explosion.
Feb. 24	Pringle, M. C.	Gallatin	Northwestern Improvement Co.	Miner	*Injured on shoulder by falling coal.
Apr. 15	Ingram, Samuel	Gallatin	Northwestern Improvement Co.	Miner	*Face and hands burned by gas explosion.
Apr. 15	Somers, Joseph	Gallatin	Northwestern Improvement Co.	Miner	*Face and hands burned by gas explosion.
July 18	Lindsay, Thomas	Gallatin	Northwestern Improvement Co.	Miner	*Face burned by gas explosion
May 17	McKinney, Harvey	Cascade	Nelson Coal Company	Miner	*Collar bone and three ribs broken by fall of coal.
Apr. 22	Broscheit, Christ	Cascade	Nelson Coal Company	Loader	*Ankle broken while pushing empty car; car ran off track.
Aug. 21	Huseby, Ben.	Cascade	Nelson Coal Company	Miner	*Injured by fall of slate and coal.
Jan. 30	Salmon, James	Cascade	Cottonwood Coal Company	Driver	*Fell from car and left ankle bruised.
Feb. 9	Baluka, Joseph	Cascade	Cottonwood Coal Company	Driver	*Left leg broken in trying to stop loaded car.
Feb. 26	Gustafson, Emil	Cascade	Cottonwood Coal Company	Mach. hlpr.	*Small bone of left leg broken by fall of coal.

FATAL AND NON-FATAL ACCIDENTS FOR THE YEAR 1906—Continued.

Date.	n	Name.	County.	Name of Company.	Occupation.	Nature of Accident.
June	29	Ahlberg, Gus.	Cascade	Cottonwood Coal Company	Loader	*Head bruised and arm broken by fall of coal and slate.
June	1	Viano, Gust.	Cascade	Anaconda Copper Mining Co.	Miner	*Right arm broken while riding on trip; ran into door.
Apr.	28	Ruffner, Lester	Park	Anderson & Evans Mines	Miner	*Bull wheel pulled out; struck by rope, arm broken in two places.
Apr.	28	Smerky, Gabriel	Park	Anderson & Evans Mines	Miner	*Scalp wound and skull fractured; same accident as above.
Jan.	31	Bradish, Peter	Park	Montana Coal & Coke Company	Miner	*Hip broken by fall of rock.
June	14	Petrin, Louis	Park	Montana Coal & Coke Company	Miner	*Back and stomach injured, squeezed between car and rib.
Apr.	25	Gergeric, Nick	Park	Montana Coal & Coke Company	Miner	**Killed by contact with trolley wire.
Oct.	26	Alexander, John	Park	Maxey Bro.'s Mine	Miner	**Killed by fall of coal.
Feb.	7	Sheppard, R. I.	Valley	The Holdal Mine	Miner	*Leg broken in two places by fall of roof.

Note—* Non-fatal, 46; **Fatal, 13; Total Accidents, 59.

The classfication of the accidents is as follows: Fall of roof and coal, 14; injured by sheave wheel, 4; injured by moving mine cars, 5; injured by gas explosions, 4; prostrated or asphyxiated by gas, but recovering, 14; injured by roller on slope, 1; injured by mining machines, 3; injured by falling timber,1. The fatalities were as follows: Asphyxiation, 8; contact with electric wire, 1; fall of coal and roof, 4.

Claude Fortune was killed at Mondak, Valley county, March 24, 1906. This fatality cannot properly be termed a mine accident, as the man was digging coal from a side hill, and the surface earth fell on him. There is no mine in that vicinity, but there are many holes and shallow openings into the lignite beds from which people extract their coal.

John Tierney was found unconscious in the Anaconda Copper company's Belt coal mine, and died shortly after being taken from the workings. On the evidence of Dr. Vidal, the attending physician, the coroner's jury decided that the man came to his death from a stroke of apoplexy.

Mr. W. F. Davis, employed by the Northwestern Improvement company in the mines at Red Lodge, was injured on June 13, 1906, while trying to put the transmission rope on the sheave wheel. He had a piece of rope attached to the transmission rope and wound about his hand. The transmission rope being set to traveling, and being unable to unwind the rope from about his hand his arm was wound around the shaft and broken. The recovery was complete.

Harvey McKinney and John King were working together drawing a pillar, working on a staging raised about 6 feet from the floor and about three feet from the roof, mining with a pick up to a powder crack, when about three-fourths of a ton of coal fell over and onto Henry McKinney.

Christ Broscheit was loading in room No. 5, back entry of main entry, the loaded car had been run out and he was pushing in an empty and ran it off the end of the track, the car falling on his ankle and breaking it.

James Salmon had his angle injured while pulling a car out of room No. 1, butt entry off second south entry, and while going around the switch with the car he fell off and was injured.

Joseph Baluka, a driver in the Cottonwood Coal company's mine at Stockett was hauling a car out of No. 7 room off No. 10 butt off No. 7 south entry. There is a slight grade to the entry where it is necessary to stop the car, and when coming out of the entry he jumped off the car to stop it, and was struck by the car, breaking his left leg.

Emil Gustafson had the small bone of his leg broken while he and his partner were mining in a room in the First north right back entry. There was a slip or water crack running

from the roof down through the face of the coal, and when the second board was cut the coal came down, falling upon him.

Gus. Ahlberg, a loader, was working in the 6th butt of the north entry, loading a car, when a piece of coal and draw slate fell from the side of the vein and broke his arm.

Gust. Viano, working for the Amalgamated Copper company in the coal mines at Belt, was riding on the front end of a trip which struck a door, breaking his arm. He returned to work in the course of a few weeks.

Lester Ruffner and Gabriel Smerky, who were injured in the Anderson & Evans Trail Creek mine on April 28th, contrary to the custom that allowed the men to ride up on an empty trip, came up the slope on a loaded trip, and when about 100 feet from the mouth of the entry, the bull wheel broke, letting the trip fall back down the slope. The rope, in straightening out, struck Mr. Ruffner, breaking his arm in two places and Mr. Smerky was injured in rolling down the slope. The other occupants of the trip jumped and escaped serious injury.

On the 26th of April, inst., the inspector was called to Aldridge by the announcement that a miner had been killed by coming in contact with a live wire. The inspector went to Aldridge and in company with Mr. Dan Short, the coronor, went to the mine and examined the conditions there. As nearly as could be ascertained, Mr. Nick Gergeric, who was killed, in company with a brother and several miners, were coming out of the mine, when the former got on a motor trip that was going out, and on being warned that he might get squeezed against the roof, got off and stepped over to the side of the entry where there is a passing branch, and his head came in contact with the bare wire of the trolly, killing him almost instantly. The riding of trips is prohibited by the company. The coroner's jury found that the man came to his death by coming in contact with the live wire and by falling with force against the floor of the drift.

The accident at Maxey's mine at Chimney Rock in the Trail Creek field, which occurred on the 23d of October, when Mr. John Alexander, a miner, was killed, was caused by a fall of coal from the face. Investigation by the inspector convinced him that Alexander, who was working alone, was in a stooping position when coal that had been left up for the roof, along

with the face, caved and crushed him. The mine had been idle for the past couple of years, and had just been put in operation by Maxey Bros., and they were anxious to get their product on the market and commenced the extraction by splitting the pillars on the entry and taking a skip up as far as the first crosscut, which is up about 30 feet, intending to draw the balance of the pillar coming down. The slope of the pitch is between 40 and 50 degrees, and with the height of the seam, running from 8 to 9 feet, is an extremely dangerous method of working, especially after the coal has stood for so long a time.

Mr. R. I. Sheppard was injured in a mine that is commonly called the Holdal mine, though no one seems to claim ownership to the property. The accident occurred on the 7th of February, and was investigated some days later by the inspector, who was in the vicinity of Mondack investigating the death of Mr. Claude Fortune. The accident was caused by the fall of the roof, Mr. Sheppard's leg being broken in two places.

Sam Dale, the mine foreman of the Bridger Coal company's mine, was seriously injured in the mine by being severely burned with fire damp. The mine is worked on the long-wall plan and gas is sometimes found in variable quantities in the tight ends. On a Monday morning after the mine had been idle during Sunday, Mr. Dale went into the face of the workings with a naked lamp, disregarding the notice that had been posted that morning by the fire-boss, and the gas igniting from his lamp, was seriously burned about the face, hands and body. On my first visit to the mine in the early part of this year, Mr. Dale had about recovered.

Ed. McDonald with his partner, W. G. Jarret, were working in room 19, on second west entry in Mountainside mine, a property of the N. W. I. company at Chestnut. The pitch of the vein is about 60 degrees, and they work the rooms up keeping them filled; timbering only for the manway and chute. The coal is 20 feet thick here and it is practically long wall work; little if any pillar left between the rooms; punching a hole through in the top of the stump for air. The center of the room is kept in advance of the ribs and timbered with sets up against the face in order to avoid the extra amount of shoveling of coal toward the chute, the miners sometimes took too many chances in working off these sides, allowing them to

cave occasionally. Mr. Ed. McDonald, was a good, practical miner. He had worked in this (Chestnut) field for several years, but was taken unexpectedly with a cave and buried beneath 20 to 25 tons of coal, killing him. This method of working was to say the least, extraordinarly dangerous. The inspector asked that this method be discontinued, and this will be done as soon as it can be arranged.

Sam Ingram and Joe Somers were working together in room No. 11, second west entry, in the Mountainside mine. The fire-boss had examined their place and had marked up gas and had left word that he was going on the other side of the mine to attend to another place where he had found gas and then return and get the gas out of Ingram's and Somer's place. Somers and Ingram went up to their place and Somers brushed out the place—he was in the dark—and hollored for Ingram to bring up a light, which he attempted to do, and fired the gas. Ingham's face and hands were badly burned. He was idle one month. Somers was not burned quite so badly; he was idle about two weeks.

George Dracolich reported to this department, in annual report, burned by explosion of gas lit by pit lamp, idle one week; also Thomas Lindsay, who is reported idle three weeks was not reported to this office at the time and this report is not in detail.

Thomas Simpson, killed by fall of roof. The only particulars, in fact, the only information received concerning same is that contained in the circular sent out asking for the production of coal for the first 10 months of 1906, and the accidents for the same period. Mr. Sam Schultze says: One man killed Oct. 1, 1906. Name, Thomas Simpson; room No. 1; neglect to timber; Irish Canadian; married; have no copy of inquest. This is a small proposition and it is presumed they were not familiar with the mining laws.

Peter Moree, an employe of the Bridger Improvement company at Bridger, working as a roller greaser; one of the rollers came out and struck him on the leg, breaking a small bone. This information was not sent to this office from the company and is not as complete as it should be.

This department has information, but no dates, of accidents to five different persons employed by the Gebo Coal company.

The first information given this department by the company of any accidents, was in the circular sent out gathering statistics for the biennial report. A footnote on the circular says: "One man, broken leg, died from other causes—the two others one had broken leg from fall, and one crushed his foot working on mining machine." One of the accidents in the above, reported a man with broken leg on April 20, and man died on May 5th, following with abscess of the liver. This may be the case—the accident not being reported at the time—the inspector after hearing of the accident by chance, might have labored under the impression that the man died from the accident received in the mine.

Such cases should have a coroner's inquest, and of course that means the inspector would have been notified and would have had an opportunity to have investigated the case, and have testified at the coroner's inquest as the law contemplates and prescribes he should do.

It must not be presumed that the inspector is trying to stick the company or even to exhonerate them by his investigations. In cases of this kind our duty is to try and find out the cause, and if possible, where the company is negligent, in matters of this kind to adopt methods to prevent a recurrence of such accidents.

The report of the accident to Nat. Danielson was not sent to the office. Owing to a press of work in other parts of the field we have been unable to visit this neighborhood, Fergus county, as often as we desired to and gather information pertaining to the accidents in detail, and in person.

Andrew Hill, Finlander, a miner, was killed in the Red Lodge mine on March 20, 1906. He and his brother William worked in room 24, third west entry, in No. 5 vein. The method employed here where the vein is about 11 feet thick is to work six feet high of coal in driving the room up and timber up the balance of coal for roof. Andrew and his brother had finished driving their room up and were bringing back the top coal. They would cut off the top of the timbers and let the top coal fall down. Above this top coal there is fire-clay roof and this also caves. They were trying to get coal down to the car to load, that was above where timber had been cut and in crawling under the top coal, Andrew Hill must have jarred against and

caused a loose piece of coal three feet by three feet, eighteen inches thick to fall on his head and shoulders, causing injuries from which he died. The coroner's jury asserted that the accident was unavoidable. This is a case where the inspector after receiving notice of the accident made all possible haste to repair to the scene and make investigation at the place of the accident, only to learn the coroner's inquest had been held at 10 a. m. of the day and just before my arrival.

An extended write-up of the accident or disaster that caused the deaths of Mr. Terry Flemming, Mr. J. E. Bracey Mr. William Bailey, Mr. Roy Carey, Mr. Alvin McFate, Mr. Mike Garrich, Mr. Thomas Skelly, and Mr. Matt. Reikka, is contained elsewhere in this report. These are the men who lost their lives by poisoning and asphyxiation. Mr. William Tarling, Mr. H. L. Bolyard, Mr. Joseph Woods and Mr. Matt Kintalla, were of the 13 original day shift that went into the mine to fight fire on the morning of June 7. Messrs. Tarling and Bolyard were carried out unconscious; Messrs. Woods and Kintalla managed to crawl out unaided. Messrs. Haggerty and Scotty, were two of the night shift that had been fighting fire and were overcome by CO in the water level. Mr. Tom Atherton, was one of the first rescuers to try and get the men out. He had been down on the incline and saw all of those who were afterward brought out dead. At the time he first got down to them all the boys were alive, he thought, except Mr. Garrich, whom he thought dead. Upon discovering the condition of the atmosphere, he tried to get out alone, and when within 350 feet of the fan, laid down, face downward and was removed unconscious several hours afterward by a rescuing party. He recovered after several days. Mr. Dan Davis and others who were overcome while trying to effect a rescue of the unfortunate men on the incline, fully recovered in a day or two.

On June 4, the carbonic oxide generated from a fire in room 22 of 4th east entry in No. 4 vein in the N. W. I. Co.'s mine at Red Lodge, vitiated the current of air that passed room 22, into the face of the 4th east entry and was taken down to the 5th east entry through room 67 that connects these two lifts with each other. Several of the miners were prostrated. It was only by the greatest effort that the entire force (over 100 men) were gotten out of the mine, without very serious results.

It was in answer to a telegram received from General Superintendent Pettigrew that caused the inspector to be on the ground when the disaster of June 7th occurred at the same mine. At this time among those who were considerably affected were: William Haggerty, mine foreman; George White, fire-boss; Valentine Krajacich, Charles Pollack, Hugh Smith, Baltus Mansburger, miners. There were others whose names were not learned.

REPORT OF MINE INSPECTIONS.

Section 3353 of the Political Code of the State of Montana, says: "For all coal mines in this state, when more than six men are employed, other than the owners or operators of such mine, whether worked by shaft, slope or drift, there must be provided and maintained in addition to the hoisting or opening, a separate escapement shaft or opening to the surface, or an underground opening or communication between every such mine and some other contiguous mine, as may be approved by the mine inspector, as coming within the requirements of this chapter, which openings constitute two separate and available means of ingress and egress to all persons employed in the mines, and all passage ways communicating with the escapement shafts must be at least five feet wide and five feet high."

This section of the code is not obeyed in spirit by some of the coal mine companies of the state. The same old coal mine story of driving double entries, using one for main haulage and the other supposedly for a return airway. The practice of pulling out the track in the back entries and allowing them to fill up with falling roof, heaving bottom and coal sluffing from the sides, is still in vogue.

Upon assuming the duties of coal mine inspector and endeavoring to go through the back entries or air-courses in some of the mines, I found the undertaking a physical impossibility, the floors and the roofs having come together until the dirt between them was almost as solid as the coal that had originally been removed from the place. To obviate the necessity of reopening, and in some cases retimbering these airways, rooms were driven through from one lift to another and used as air-

ways, leaving one airway from the slope in two parallel lifts and the double entry maintained in a manner near the face of both lifts, while developing the territory in which to open rooms.

There are several things that might happen in cases of this kind that would prove disastrous. Any serious cave in the room used as an airway would seriously interfere with the entire air circuit. If the conditions are unfavorable to keeping an airway open—that is of the ordinary width, say 8x10 feet wide—it certainly does not improve conditions to try and maintain an air course in a place driven up from one lift to another 20 to 25 feet. If a blockade by fall or runaway trip in either of the stems of the originally driven double entries, that would effectually blockade the air, it is my observation that such maintained or short-circuit airways are not in condition for men or animals to travel in. Another very serious objection to this mode of ventilation is that if a fire should break out in, say, the intake part of the airway, the men could not be gotten off that circuit before serious consequences would in all probability occur.

While this system may in instances be of advantage in connection with a properly maintained double entry system in affording temporary relief in case of a serious cave or obstruction, to depend upon this mode of developing and prosecuting work is, to say the least, poor mining and business judgment, and is certainly taking serious risks with the lives of the miners. With railways the tendency is toward the double track system. It would be profitable to the mine operators and a blessing to the miners of Montana if the system should be adopted for the coal mines. Then there would be no question, where the mechanical appliances are of sufficient capacity—and in Montana this is generally the case—as to the sufficiency of the air supply, and more than the present law requires. The area in the back entry would be large enough to supply air either as an intake or return for the main haulage—which of necessity must be kept open in order to haul the coal—so that if the road is maintained in the back entry, it is fair to presume it will be a paying investment for the operator, as with the double road there would not be the congestion that so often occurs on the single road when a trip is derailed and all behind have to wait. The least that might be done to correct the evil, would be to leave switches

in the slants and double stoppings; or better, two doors, so that a periodical cleaning-up can be made whenever it becomes apparent that the area in the back entry is being lessened or blocked up. This question is becoming serious in some of the mines of this state, and has been constantly growing more serious for some years. The condition is partly accounted for in this way: When a mine is opened the chief object in view is to get the coal out at the lowest possible cost, and the only regard paid to the mine is the compulsory necessity of keeping the haulage-way open, and possibly, technically complying with the legal requirements as to airways. When there is a change in the management, as is sometimes the case, the incoming management usually finds advanced mine workings, poorly cleaned, timbered and drained airways, and an established cost of production that it is expected will be maintained. Inheriting the conditions stated, and others that could be mentioned, with machinery becoming worn, necessitating repairs all along the line and the haulage becoming longer, the maintanance of proper and safe workings and the established tonnage cost, are found to be an impossibility. These bad conditions grow steadily worse, hardly being appreciated by the management or the foremen who come in constant contact with them, and by the time there is a third or fourth change of management, and the conditions have grown so bad that the inspector is compelled to positively order changes that are essential—reclaiming, retimbering and putting the back entries in shape so as to get the same area in them as in the haulage-way, etc.—work upon which at times the very life and continuance of the mine itself depends, the corporation thinks the order a move to bankrupt the company.

It does not require any complicated mathematical calculation to ascertain the area and capacity of airways of this character. If the vein is six feet thick and the entries are eight feet wide—8x6 feet—one lineal foot contains 48 cubic feet. This must be maintained in the haulage way. The back entry was originally the same size, but being allowed to cave, or the bottom to heave, or the coal to sluff from the sides, will sometimes have its area reduced to a space as small as 3x4 feet, affording but 12 cubic feet to each linear foot, and this space must act as the return or intake for the 48 cubic feet per lineal foot of the haulageway.

It became necessary to order a general cleaning up of just such

airways in the Red Lodge mines of the Northwestern Improvement company, and the results were immediately apparent, and are today, in the improved ventilation of the mine. After the disaster in these mines, which occurred on the morning of June 7th, 1906, the management was requested to change the course of the intake airway so as to avoid having to pass a firewall built in the left back entry below an old firewall and down to the Fifth east back entry, and the request was complied with. The opening of the Fifth east back entry, which was included in the same written order, has not yet been complied with.

The condition of the air in the Red Lodge mines, at the time of my first visit was, according to measurements taken at that time, January, 1906, as follows:

Intake, No. 1½ mine, 12,941 cubic feet; return, 19,256 cubic feet. (Intake measured near the face; the difference in the measurements represents leakage.)

No. 4½ water level intake 8,892 cubic feet; measured at C. C. face, Third west, opposite 48-room, 5,355 cubic feet; return, 9,180 cubic feet.

Intake from No. 2 fan, ventilating Fourth west in 5-vein, and Fourth and Fifth east in 4-vein, measured in rock tunnel, 13,230 cubic feet; C. C. at face Fourth west in 5-vein, 4,282 cubic feet; return from Fourth west in 5 vein, 7,923 cubic feet, and east side in 5-vein, 6,248 cubic feet.

This current is from No. 6 electric fan and from No. 2 steam fan, and is required to supply Fourth east in 4-vein and Fifth east in 4-vein, 24,930 cubic feet.

Intake in back entry of No. 4 slope, 18,400 cubic feet. This current only ventilated the Sixth east, working five or six men.

All return currents measured on No. 4 slope, 43,520 cubic feet.

There was considerable carbonic acid gas (CO_2) in the Fifth east entry, making it difficult to keep a light burning, at this time.

On October 19th, 1906, the air measurements were as follows:

Intake measured on the first overcast on No. 4 slope, 34,542 cubic feet; overcast Third east, 32,589 cubic feet; overcast Fourth east, 29,700 cubic feet; overcast Fifth east, 22,353 cubic feet; C. C. between Fifth east back and main in 4 vein, 23,417 cubic feet; overcast 67 Fifth east, 22,869 cubic feet; 109 room Fifth east (this is practically the face of the entry), 17,078 cubic feet; top 67 room, 20,970 cubic feet.

Measurements taken on the 20th of October, 1906, were as follows: Return—Fourth and Fifth east, 20,608 cubic feet.

There were 109 men and 5 mules or horses on the Fifth east, 31 men and 1 mule on the Fourth east, making a total of 140 men and 6 animals supplied with this current, or a total of 20,790 cubic feet of air, the law requiring for this number of men and animals 17,000 cubic feet.

Another objection to the method complained of is in shortening the circuit and not keeping the back entryway open the same as the haulageway. Section 3557 of the Political Code, requires that "the current of air in mines must be split so as to give a separate current to at least every 100 men at work."

On October 20, 1906, the intake from No. 2 steam fan measured in the rock tunnel from 2-vein to Fourth east in 4-vein, 30,213 cubic feet. Part of this current is conducted to the Third east in 4-vein, and through the rock tunnel in Third east in No. 4, to 5- and 6-veins, ventilates the Third east in 6-vein, and the balance is conducted through the rock tunnel from Fourth east in 4-vein, to Fourth west and Fourth east, in 5-vein, and measured in the rock tunnel, 16,900 cubic feet. The return companion tunnel measured 18,241 cubic feet. No record could be secured at the face of Fourth east in 5-vein. There were 24 men on this split. In the last C. C. in Fourth west in 5-vein, 2,565 cubic feet; 27 men and one mule. Return Third east in 6-vein, 4,275 cubic feet; 27 men and one mule.

On October 22d, 1906, the following measurements were taken:

Intake No. 1½, 10,379 cubic feet; inside rock tunnel to 1-vein, 1,639 cubic feet; back entry of No. 1½, inside, 3,498 cubic feet; return at fan, 9,909 cubic feet: 21 men and one mule.

Considerable black-damp was constantly being generated and a considerable portion of it lodged in the Fifth east entry, as it was the return airway; but, as stated, and according to the measurements taken, showed decided improvement both as to quantity and quality. While no written orders, except as previously stated, have been given to any one connected with this company, I have from time to time called the attention of those supposed to have charge of the air currents to the falls, insufficiency of current, timbering, drainage, etc.

The mine at Bridger, operated under a reorganized company and new management, has been improving conditions regarding ventilation and escapes, and I expect shortly to find conditions very greatly improved, as compared with conditions at the time of my first visit. This is one of the few coal mines in this western country that works exclusively on the long wall system. The mine is being put in good condition.

The Mountainside mine at Chestnut has had its ventilation improved since my first visits. An electric fan has been installed, the air courses cleaned up and timbered, and another fan is to be installed at the Chestnut water level, which, when placed over an upraise air course that was driven from the Mountainside levels, will aid the air currents materially.

There is a good deal of gas generated in this mine, and were it not for the constant vigilance of the foreman and fireboss, there might be serious results. The timbering and drainage is fairly good.

The Storrs mine has not been operated extensively for some time, but development has been carried on constantly. When the property is set to producing, it is expected that its airways will be put in good condition.

The Mountain House mine, under lease to Evans & Anderson, also produces gas, but no trouble has been experienced from it. The ventilation, timbering and drainage are fair.

The ventilation, timbering and drainage of the Kuuntz mine is in tolerably good condition.

The Joliet mine is a small property located between Joliet and Gebo and creates its air current with a furnace that has recently been established. The timbering and drainage is fair.

The Gebo mine has changed superintendents and mine foremen so often that securing improvements or bettering the ventilation, when asked, has received very slow and tardy compliance, but it is anticipated that there will be an improvement in

this respect under the present management. The mine does not employ a large force of men, so bad conditions are not so noticeable. The roof is good and requires very little timbering.

The McCarthy mine at Fromberg, adjoining the Gebo property, is working a few men. During the warm weather the ventilation is aided by a furnace, and this is not required during the colder periods. The current is ample for those employed. There is no water to contend with and little timbering is required.

In the Nelson mine at Sand Coulee, the ventilating current is ample for the men employed in the mine, and the last measurements demonstrated that the air is properly distributed. It was reported to this department that he old workings of the Sand Coulee mines are filled with water and that the workings of this property are closely approaching the former territory. As a precaution, to prevent the possibility of breaking into the flooded workings of the other property, I ordered drill holes to be kept well ahead of the work and bore holes to the side. Little timbering is required in this property, and the mine is well drained.

In the Gerber mine at Sand Coulee the air is fair, but might be improved, and improvements to this end are being made. The drainage and timbering is good.

The mines of the Cottonwood Coal company at Stockett are worked extensively and are in generally good condition with a fairly good volume of air. The extraction of coal is made with machines and the mine is worked under established system, with machine men, shooters, timbermen, tracklayers, loaders, etc., each man being confined to his particular line of duties, and in order to maintain the output of 2,000 tons per day, with the present development, the foreman claims it is necessary to shoot down the coal as soon as it is ready for firing, and this method keeps the air currents vitiated with the smoke of the powder. I have taken the matter up with the superintendent and expect to secure a change in the method. The timbering of the mine is good and there is little water.

The Aldridge mine has been operated for several years under different managements. The field has been considerably disturbed and this makes it difficult to keep the haulage and airways open, disturbing and shortening the air supply. The present management has done a good deal of work to improve conditions, but has a difficult task. The drainage and timbering is fair.

The Amalgamated company's mine at Belt, on account of its advanced and extensive workings, has had a rather limited volume of air, but this will be fully corrected with the completion of the upraise now being made from the rear workings to the surface. The timbering and drainage is good.

The Calone & Schmauch mine is ventilated by the aid of a small furnace, and the timbering and drainage is good. The mine is small and only employs a few men.

The Millard, Orr and Richardson mines at Belt and Armington are dependent upon natural ventilation, and while it is not up to standard, as the properties are small and but few men are worked in each, there does not appear to be any detrimental effeect. The drainage and the timbering are good.

With one or two exceptions the mines mentioned are the large producers, and properties that are, generally, equipped with mechanical appliances for ventilation There are a number of smaller properties that are mostly operated only during the winter months, employing from two to five men, and placing their output on the local domestic market, that are dependent entirely upon natural ventilation for the present. Some of these properties, notably Gebo's mine at Gilt Edge, Ayer's mine at Havre, and the Hadelan and Alcott mines at the same place, give promise of becoming large and regular producers in the near future. The Gebo mine is having a fan established to provide mechanical ventilation. Kerr's mine at Chinook, Sharp's mine at Lewistown, and many other small openings throughout the state, as the work advances and becomes deeper and more men are employed below ground, will be obliged to adopt me-

chanical means of ventilation, especially during the summer months when the temperature of the atmosphere of the workings and that of the surface is practically the same.

EXAMINATIONS FOR CERTIFICATES.

Section 3359 of the Political Code of the State of Montana says: "It is unlawful for any person to act as foreman or mine boss of any mine in which inflammable gases are known to exist who does not possess a certificate from the state mine inspector certifying to his competency for managing the underground workings of mines, together with a thorough knowledge of all gases met with in coal mines and of the most approved means or appliances for controlling them, and the inspector of mines is authorized to examine all foremen or mine bosses upon their competency under the provisions of this chapter and issue his certificate to those whom he considers qualified to act as such foreman or mine boss within the meaning of this law. It is unlawful for any owner of a coal mine to employ persons underground whose duties may involve contact with inflammable gases or the handling of explosives, who have not had experience in such duties, unless all such employes are placed under the immediate charge and instruction of such number of competent men as to secure the safety of other persons employed in the same mine."

In compliance with the provisions of the statutes, examinations have been held and, realizing the expense and inconvenience to applicants that would attend an enforced visit to the Coal Mine Inspectors' office at the capitol, examinations were conducted at the different coal mining towns when visited by the inspector on his regular rounds of inspection. As a result of such examinations the following persons have been granted certificates of competency by this department:

S. M. Moore, Great Falls.
John Walker, Chestnut, Montana.
Hirst Beever, Chestnut, Montana.
William Haggerty, Red Lodge, Montana.
John Good, Bridger, Montana.
Charles Sederholm, Bridger, Montana.
C. C. Fenwick, Bridger, Montana.

In general, the interrogatories of these examinations have been as follows:

1. What experience have you had as mine foreman or fire-boss?

2. What instruments are necessary for a mine foreman in the management of a mine?

3. Upon what does the method of opening out a coal field depend?

4. Give the general points which determine the location of a shaft?

5. What conditions of top and bottom require the largest pillars?

6. What should be the minimum size of slope pillars?

7. Of what material would you construct permanent stoppings or brattices to secure duration and economy?

8. Give a sketch of a set of timbers where top and side pressure is expected.

9. Give a sketch of a set of timbers that you would place in a wide space where it is deisrable or necessary to dispense with the center prop.

10. Does it make any difference in the strength of a post, whether the big end of a post is next the floor or the roof?

11. Where there are several seams to be worked in the same field by the pillar method, which seam should be worked first?

12. What precaution should be taken if some of the lower seams are worked at the same time?

13. In approaching abandoned workings supposed to be filled with gas or water what precautionary measures are necessary?

14. What gases destructive of life or injurious to health are encountered in coal mines?

15. How would you detect fire-damp in a mine?

16. Give the proportions by volume of air and gas that make the mixture explosive; also the percentage of gas that can be detected with a safety lamp; and what is the most violently explosive mixture?

17. Would a mixture of fire-damp and air, just below the explosive point, become explosive when suddenly compressed, as by the discharge of a heavy shot, a sudden and heavy fall, or by a heavy explosion in adjacent workings?

18. How do you detect black-damp generated in mines?

19. What produces white-damp (CO) in dangerous quantities in a mine?

20. How do you detect white damp (CO)?

21. How is sulphuretted hydrogen gas (SH_2), or stone-damp, produced, and what is the danger attending its presence in mines?

22. What is after-damp, and how is it produced?

23. Which of the gases named do you consider the hardest to contend with, as regards ventilation, and why?

24. Which is the best for an intake airway—one opening 8'x8' or two openings 4'x8', and why?

25. What is meant by natural ventilation, can it be depended upon, and if not, why?

26. Where will an exhaust fan give best results—at the bottom or top of a shaft?

27. With the same power in operation, how can you increase the amount of ventilation in a mine?

28. What method would you adopt in opening a new mine, for ventilation—single, double or three-entry system, and why?

29. State what contributes most to poorly ventilated mines?

30. Referring to the previous question (29), what would you think necessary to obviate trouble and to keep the mine properly ventilated?

31. State the Montana law regarding ventilation, the quantity of air required for man and mule, and distribution of same.

32. What is the Montana law relating to mine accidents, i. e., the duty of mine foremen or superintendents in such cases?

33. In mines where powder is used in blasting, what system is best?

34. In dusty mines what precautions are necessary, and why?

35. How would you deal with a mine fire?

36. How does a skillful miner produce more coal than an unskillful miner?

Though the law quoted was enacted with the adoption of the Codes in 1895, I am not aware of its enforcement prior to this administration, and before enforcing the law and holding examinations under its provisions, careful consideration was given the fact that many of the foremen of mines had arisen to their positions step by step, being promoted for natural ability, faith-

fulness and their practical knowledge of the duties devolving upon them, and that while their experience made them competent as practical men, they might not be informed in the technical premises that would properly be covered by such an examination, and so the examinations have been made, as shown by the foregoing list of interrogatories, almost wholly in the practical line, the technical being largely avoided. Those taking the examination, in order to pass, were required to secure a marking of at least 75 per cent.

In order to encourage those who desired to fit themselves for positions as foremen and firebosses, all who desired and made their wants known were examined and certificates granted to them.

In the older mining countries, by systems of competitive examinations and certain mental requirements for holding even lower positions, a grade of employes is obtained which is superior to the same grades found generally in this country. The result is that in emergencies the intelligent miner recognizes danger and takes steps to avoid it, whereas the less posted one sometimes suffers in consequence. The practical man is doubly armored, who possesses a good smattering of the technical side of his line of business along with his practical experience.

While, as before stated, the examinations held to comply with our law were of the practical rather than the technical, for the reasons stated, in the future we hope to bring up the standard of these examinations to meet the more technical requirements that every miner should possess, for the safety of himself and those dependent upon him. We venture the assertion there will be fewer accidents among the miners if more interest is taken and better advantages are offered for acquiring a better knowledge of their business.

The I. C. S., with headquarters at Scranton, Pa., is doing a good work in this line. I have perfect confidence in the I. C. S. and would advise any one who desires a knowledge of the coal mining business (or any other branch they teach) to enroll with them. I do know this: If anyone wants to learn, the I. C. S. can and will teach him.

The law of Montana requires the State Coal Mine Inspector to have had ten years' practical experience in coal mining, and to be a graduate of some recognized school of mines and mining

engineering. I had had twenty years' practical experience in various capacities in mines, but did not possess the technical requirements until I took a course in the I. C. S. I am positive of the fact that I would not have received the appointment of State Coal Mine Inspector but for having taken the coal mining course.

For the miner who has not the means to attend a School of Mines, and who desires to obtain the knowledge of up-to-date methods of mining, an excellent opportunity is offered to employ leisure time, evenings and idle days, and in a short time acquire a good knowledge of mines and mining. Two hours each day spent in study means 60 hours a omnth, or about 10 whole school days a month. It will be time well spent, even though nothing better comes of it than a thorough understanding of the business.

RECOMMENDATIONS.

It is the opinion of the State Coal Mine Inspector that all managers, superintendents, foremen, bosses, firebosses of coal mines, whether the mines are gaseous or not, should be obliged to undergo an examination that will demonstrate their knowledge of the duties that their respective positions will impose upon them, and that such examinations should be conducted by a board created for the purpose, the board to be composed of the State Coal Mine Inspector, one mine superintendent or manager, and one miner, the resident or presiding judge of the district court of the district wherein such examination is to be held to appoint the last two members, and it is recommended that Sec. 3359 of the Political Code be amended so as to conform to these suggestions.

A great many of the dangers of the coal mine would become largely nugatory if our statute would provide, as do the mining laws of Wyoming, that every part of a working face shall be visited by the foreman in charge at least every other day. These compulsory visits result in the foreman who is responsible for the working condition of the mine, being kept perfectly familiar with every part of the workings, and places him in a position to intelligently direct improvements and to take precautions that may be necessary to avoiding accidents and disasters. That this

law would be beneficial to the corporation as well as to the men, is patent.

Another defect in our mining laws, and which should be remedied, is the absence of a law requiring timber to be cut and squared on both ends when delivered at the mouth of the workings. The absence of prepared timber when hastily required, often works a hardship on the miner by allowing the roof to break when otherwise it could have been preserved; and having timbers cut and delivered in the proper length, in the room. will often avert the misfortunes and the accidents that so often befall the coal miner.

Though it should, the Montana laws do not make it compulsory to make crosscuts or break-throughs, and it should provide that these be constructed not more than sixty feet apart in rooms, and where it is desirable to drive them farther apart in entries, brattices (cloth preferred) should be maintained to conduct the air current to the face of the main and back entries; but under no circumstances should break-throughs or crosscuts in entries be farther apart than one hundred feet.

Sections 39 and 40 of the Kansas laws should be enacted into the coal mining laws of this state. Section 39 reads: "Standing or stagnant water shall not be allowel to remain in air courses, entries, travelways or rooms. Obstructions of any kind must not be placed in crosscuts, rooms or entries used as airways. And in case of a fall of roof, or where the sides of such airways cave in, it shall be the duty of the mine boss or agent in any such mines, to cause such falls or obstructions to be removed immediately and the roof and sides made secure." Section 40 of the laws quoted, says: "All main airways in any of the underground workings shall be examined at least twice a week by the mine boss or agent and a report of such inspection shall be forwarded to the office of the coal mine inspector at least once a month."

For the purpose of determining the amount of air traveling in the mine and at the face of each working place, the foreman, assistant, or fireboss or some competent man, should be compelled by law to take the measurements of the air current, with an anemometer at least once a week, and better, twice a week, as required by the Kansas law, and the records of these measurements should be kept at the mine office and a report of the

same sent to the state coal mine inspector at least once each month, such reports to give the date of measurements, the amounts of air per cubic foot per minute, the measurements to be taken at the foot of the downcast and in the last crosscut at the face of the entries; and, in long wall workings, in the last room in each division. The purpose of this recommendation is to compel those responsible for the condition of the mines, such as superintendents, foremen and firebosses, to be familiar with the air currents and their condition. A law of this character should apply to all mines employing fifteen or more men underground.

Article II, Section 342, Political Code, makes the Secretary of State ex-officio sealer of weights and measures. Section I, House Bill 25, Session Laws of 1901, entitled "An Act Providing for the Employment of Check Weighmen at Coal Mines, Prescribing His Duties and Providing Penalty for Violation Thereof," the latter part of the section says: "Whenever the inspector of mines, or deputy inspector of mines, shall be satisfied that the provisions of this section shall have been willfully violated, it shall be the duty to forthwith inform the prosecuting attorney of such violation, together with all the facts thereto relating * * *." As the law regulating the inspection of scales now stands, it is a dead letter. Provision should be made for the proper and regular inspection of scales that are used in the weighing of mine coal, either by making the present law operative or by giving this department the proper authority and providing it with the facilities and the financial ability to attend to such added duties.

It is the experience of the department that it is difficult to secure correct and prompt reports relating to the coal mining industry of the state, and especially so from the smaller producers. The securing of this data promptly and for the dates requested, is a necessity to the collection and preservation of the coal mining statistics of the state, and there should be a law enacted requiring coal operators to promptly and correctly return such statistical information as is asked of them by this department.

The department believes that any laws adopted in the future for the regulation of coal mines, and those laws that are now on the statutes, instead of depending for their enforcement upon the issuing of an injunction, should have fine and imprisonment

penalties attached. The enforcement of laws by injunction reacts against those whom the law is presumed to protect. It cuts off the revenue of the operator and the miner and the supply of the consumer, and should only be called into operation when lesser penalties have failed to secure obedience to the laws.

There are no laws in the state regulating the handling of explosives and blasting in coal mines, and this should be given attention by the next legislative assembly.

THE DUTIES OF CORONERS.

The State of Montana.
Office of State Coal Mine Inspector.
J. B. McDermott, Inspector.

Helena, Montana, Oct. 10, 1906.

Sir:—Section 586, Political Code of Montana, among other things says:

"Upon receiving notice of a serious or fatal accident, the inspector in person, or the deputy, must at once repair to the place of accident and investigate fully the cause of such accident, and where possible to do so, the inspector or deputy inspector shall be present at the coroner's inquest held over the remains of the person or persons killed by such accident and testify as to the cause thereof, and state whether, in his opinion, the accident was due to the negligence or mismanagement of the owner or person in charge."

Section 49 of the Political Code, laws of 1901, Senate Bill 106, after enumerating some of the duties of the Coal Mine Inspector, says:

"* * * and it shall further be the duty of the said coal mine inspector after being notified by a justice of the peace or coroner, in the districts where accidents may occur, to immediately investigate the same."

From the above it would seem that the coal and metalliferous mine inspectors would be obliged to attend and testify before the coroner's inquest whenever an accident occurs in their respective departments.

Several times during the past couple of years fatal accidents have occurred and the inquests have been held and the verdicts rendered, without time or opportunity having been given for the

inspector to be present to make investigation or to testify at the hearing.

Would the inquest be complete without the inspector's testimony?

Should not the coroner or acting coroner date the inquest so that the inspector could be present?

Could the coroner summon the jury, have the remains viewed and allow the body to be buried, and postpone the inquest until the inspector could be present?

An answer to the above inquiries by you would, if understood by the coroners and inspectors, no doubt be of benefit to both of the offices and save trouble and expense to the counties and state.

Respectfully yours,

WM. WALSH,
State Mine Inspector.
J. B. McDERMOTT,
State Coal Mine Inspector.

ALBERT J. GALEN,
Attorney General State of Montana,
Helena.

Department of Attorney General,
Albert J. Galen, Attorney General.

Helena, Montana, Dec. 1, 1906.

Mr. J. B. McDermott, State Coal Mine Inspector; Mr. William Walsh, State Mine Inspector, Helena, Montana.

Gentlemen.—Your joint letter of recent date received, in which you request an opinion of this office as to the duties in regard to cases where fatal accidents in any of the mines under your respective jurisdictions, and also as to the duties and procedure of coroners and acting coroners in such cases.

Section 586 of the Political Code, amended by the laws of 1903, page 181, in defining the duties of the Mine Inspectors, says:

"Whenever a serious or fatal accident occurs in any mine it is the duty of the person in charge thereof to immediately notify the inspector of mines or the deputy inspector, and upon receiving such notice the inspector in person or the deputy inspector must at once repair to the place of accident and investigate

fully the cause of such accident, and whenever possible to do so, the inspector or deputy inspector shall be present at the coroner's inquest held over the remains of the person or persons killed by such accident, and testify as to the cause thereof, and state whether, in his opinion, the accident was due to the negligence or mismanagement of the owner or person in charge."

Section 4 of Senate Bill 106, laws of 1901, page 64, in defining the duties of the coal mine inspector, says:

"And it shall further be the duty of the said Coal Mine Inspector after being notified by a justice of the peace, or coroner, in the district wherein accidents may occur to immediately investigate the same."

From the language of the above laws it is apparent that the legislatures intended that said mine inspectors would make personal investigation into the causes of death in mines coming under their jurisdictions, and give the coroner and coroner's jury the benefit of their opinions as experts upon the facts found by their investigation.

Said section 586, as amended, says:

"When possible to do so, the inspector or deputy inspector shall be present at the coroner's inquest held over the remains of the person or persons killed by such accident and testify as to the cause thereof."

If the location of the mine is so remote from the office of the inspectors, or the place where the proper inspector may be then engaged as to make it impossible for him to go to the mine and make his investigation before the body of deceased should be interred, then and in that event, the coroner or acting coroner should empanel the jury and after they have inspected the body or bodies, he should not conclude the taking of testimony and submit the case to the jury until such time as the proper mine inspector had received reasonable notice and had opportunity to make his investigation and testify before the jury.

The coroner or acting coroner has the right, after having had the jury inspect the body or bodies, or at any stage of the proceedings thereafter, to adjourn the inquest to some future date so as to give the mine inspector time to go to the place of accident, make his investigation and then appear before the jury and give his testimony.

In our opinion this procedure should be followed by coroners

and acting coroners in all inquests held by them over the remains of persons killed in the mines coming under the jurisdiction of such mine inspector.

Very truly yours,
ALBERT J. GALEN,
Attorney General.

AS TO INSPECTION OF SCALES.

Livingston, Montana, Oct. 6, 1906.

Mr. J. B. McDermott, State Coal Mine Inspector, Helena.

Dear Sir:—Kindly let me know if you can examine any of the scales at any of the mines, or is there any law in this state regarding the testing of scales or weights.

Please let me know with whom I can communicate to secure information as to the testing of scales.

Yours very truly,
THOS. GIBSON,
Pres. Dist. 22, U. M. W. of A., Livingston, Mont.

The attention of Mr. Gibson was called to Article II, Sec. 342, Political Code, which makes the Secretary of State ex-officio sealer of weights and measures, and also to Sec. 1, House Bill 25, Session 1901, and saying that "insofar as it applies to this department, will be promptly enforced at any time the conditions of the section are complied with by presenting the fact of the false weights or measures being in use; but that the department is not given initial authority of inspection, only being authorized to initiate prosecutions under the conditions mentioned in the section."

As the law regulating the inspection of scales now stands, it is a dead letter. Competent provision should be made to in some manner provide for the regular inspection of scales that are used for the weighing of mine coal, either by making the present law operative or by giving this department the proper authority and providing it with the facilities and the financial ability to attend to the prescribed duties.

AGREEMENT BETWEEN MINE OPERATORS AND MINERS.

At the annual meeting of the representatives of the several coal districts of Montana operating under the organization of the United Mine Workers of America and of the coal operators of the state, held in Helena during September of this year, a scale of prices and set of rules were mutually agreed to, the general provisions covering the hours of work, price of powder, the pay day, doctor, fines, dues and assessments, inside day, adjustments of disputes, construction and extensive repairs, tool sharpening, penalties for loading impurities, penalty for stoppage of work, preference in employment, repairs and emergency work, removal of water, delivery of cars, no new conditions to be made, check weighman, miners on other work, deaths and funerals, penalty for absence from work, provision for injured, man trips, supply cars, scale of outside day wages and scale of inside day wages, scale of mining rates. The agreement was made and signed by Mr. Thomas Gibson, president of District No. 22; Mr. James Morgan, secretary-treasurer of District No. 22, and Mr. Thomas Burke, National B. M.; and Mr. C. R. Claghorn for the Northwestern Improvement company, Mr. F. W. C. Whyte for the coal department of the Anaconda Copper Mining company and the coke department of the Washoe Copper company, Mr. George C. Hough for the Bridger Coal & Investment company, Mr. F. S. Forest for the Cottonwood Coal company, Mr. A. O. Nelson for the Nelson Coal company, Mr. Ed. Gerber for the Gerber coal mines, Mr. H. H. Griffith for the Gebo Coal company, Mr. W. H. Close for the Spring Creek Coal company. The agreement is made to expire by limitation on the first of October, 1907.

REPORT ON STATE COAL LAND INVESTIGATION.

At the request of the State Board of Land Commissioners. I visited and inspected, during the latter part of December, 1905, the state coal lands in the vicinity of Havre, and reported to the board in substance as follows: There are three coal openings upon the state lands, and from all of these more or less coal was constantly being extracted.

The first opening visited was being worked by Mr. G. J. Ayars. The tunnel or slope is driven in on the vein 500 feet, and there have been several rooms turned off and driven both east and west from the tunnel, which runs almost due north. There are seven rooms opened and being operated, five of them to the east and two to the west. The coal is of a lignitic character, runs from five to six feet in thickness, and the seam is interstratified with two bands of slate, one near the bottom and the other near the top. I measured the tunnel and rooms and made an estimate of the coal extracted, upon the basis of four feet of merchantable coal. The main tunnel has been driven 200 feet by the present management. The estimate of coal extracted, rendered in detail, was 1,893 short tons.

Prior to the Ayars management, the mine was operated by Mr. J. M. Bragg and he constructed 100 feet of the tunnel that was in merchantable coal, and three rooms, and I estimated his extraction of coal to be 515 short tons.

I submitted to the board, as a basis upon which royalty might be established, figures including the cost of mining, hauling, timbering, etc., and the market value of the coal, and also stating that the royalties received by individual owners in the State varies, according to mine and local conditions, from 6¼ cents to 25 cents, and suggested that 12½ cents per ton would be a fair royalty. Figuring four feet of clean coal, an acre in this field will contain 174,240 cubic feet.

Mr. Frank Burton has an opening that is but a short distance from the Ayars workings, the tunnel being driven in 200 feet on the seam before securing merchantable coal, and from this point being extended west of north a distance of 93 feet in good coal. Three rooms are turned off this tunnel, one to the east and two to the west, and I estimated a gross extraction of good coal at 669.8 short tons.

To the east and north a slope has been driven in the seam by Mr. H. W. Loudon, 60 feet of the tunnel being in merchantable coal, and there is one room driven to the east. I placed the coal extraction at 147.7 short tons.

DIRECTORY OF THE COAL MINES OF THE STATE OF MONTANA.

The Havre Fuel Company.

G. J. Ayars, president; J. Strain, secretary and treasurer; Frank F. Bossuot, general manager; Havre, Montana; mines near Havre.

Amalgamated Copper Company (Coal Department).

F. W. C. Whyte, general manager, Anaconda; J. J. Kinney, superintendent, Belt; mines at Belt.

Cottonwood Coal Company.

Louis W. Hill, president, St. Paul, Minnesota; E. Sawyer, treasurer; James Pearson, superintendent, Stockett; mines at Stockett.

The Northwestern Improvement Company.

Howard Elliott, president; R. H. Relf, secretary; C. A. Clark, treasurer, St. Paul, Minnesota; C. R. Cleghorn, general manager, Tacoma, Washington; Robert Pettigrew, general superintendent, Red Lodge, Montana; mines at Red Lodge.

The Nelson Coal Company.

John G. Nelson, president; J. A. Nelson, secretary; Samuel McClure, treasurer; J. N. Pierce, general superintendent. Company postoffice, Great Falls; general superintendent's postoffice, Sand Coulee; mines at Sand Coulee.

The Mountainside Coal Mines.

Operated by the Northwestern Improvement company; general manager, C. R. Cleghorn, Tacoma, Washington; superintendent, Geo. Forsyth, Chestnut, Montana; mines at Chestnut.

The Bridger Coal and Improvement Company.

George H. Hough, president; Raymond H. Hough, secretary; Geo. G. Hough, treasurer; Geo. G. Hough, general manager; Thomas Good, superintendent; mines and postoffice at Bridger.

Trail Creek Coal & Land Company.

Jos. Kuntz, president; George Cox, secretary-treasurer, Bozeman, Montana; J. E. McLaughlin, general superintendent, Chimney Rock, Montana; mines at Trail creek.

Spring Creek Coal Company.

S. W. Gebo, president; W. H. Close, secretary-treasurer; S. W. Gebo, general manager; W. H. Close, superintendent. Lewistown; mines near Lewistown.

International Coal Company.

Henry Rosetta, president; J. E. Mushback, secretary treasurer, Red Lodge; mines at Bear Creek.

Joliet Coal & Fuel Company.

A. C. Wolf, president; C. E. Anderson, secretary-treasurer; John Bergin, general manager and superintendent, Joliet; mines at Joliet.

The Washoe Copper Company (Coke Department).

F. W. C. Whyte, general manager, Anaconda, Montana; G. N. Griffin, general superintendent, Storrs; mines and plant at Storrs.

The Montana Coal Company.

A. D. Holman, general manager and superintendent; Gilkerson & Stevens, owners, Lewistown; mines near Lewistown.

Montana Coal & Coke Company.

E. A. Barth, general manager, Electric; Robert M. Magraw, superintendent, Aldridge; mines at Aldridge.

The Gerber Mines.

Ed. Gerber, owner and manager; John Rothwell, superintendent; Sand Coulee.

Zeno-George Coal Mines.

Operated by Brugger & Nugent; J. Z. Bruger, general manager; J. G. Nugent, superintendent; Culbertson.

The Sharp Coal Mines.

Operated by Sharp & Tayer; B. Tayer, manager; Wm. Sharp, superintendent; Lewistown.

The Gebo Coal Mines.

H. H. Griffith, superintendent, Gebo. This is operated under a co-partnership.

The Millard Coal Mines.

Owned and operated by H. W. Millard, Belt.

The Lewis Coal Mines.

Operated by Fred Schmauch & Co., Belt.

The Richardson Coal Mines.

Owned and operated by Matt. Richardson, Armington.

The Hoffman Mines.

Operated by Anderson & Evans, Chimney Rock.

The Schultz Coal Mines.

Owned and operated by Sam Schultz, Utica.

Alcott's Coal Mines.

Owned and operated by J. R. Alcott, Havre.

Hadalin Coal Mines.

Owned and operated by Adam Hadalin, Havre.

The Maxey Mines.

Owned and operated by Daniel Maxey, Chimney Rock.

The Harmon Coal Mines.

Owned by J. L. Harmon and operated under lease by Sells & Chambers, Lewistown.

The Kerr Coal Mines.

Owned and operated by Wm. Kerr, Chinook.

The Carbon Mines.

Owned by J. C. McCarthy, Bozeman; operated under lease by Killorn & Weber, Fromberg.

Stainsbury-Latham Coal Company.

Wm. Stainsby, general manager, Sand Coulee.

The Orr Coal Mine.

Owned and operated by Orr Brothers, Belt.

The Lewis Coal Mine.

Owned and operated by J. J. Lewis Gilt Edge.

The Peiper Coal Mine.

Owned and operated by F. E. Peiper, Lewistown.

The J. C. McCarthy Bear Creek Mines.

Owned and operated by J. C. McCarthy, Bozeman; John Smith, foreman, Bear Creek.

Bear Creek Coal Company.

C. Yegen, president; R. Leavens, vice president; B. E. Vaill, treasurer; P. M. Gallagher, secretary and general manager; Bear Creek.

Montana Coal & Iron Company.

Elijah Smith, president; Prosper W. Smith, secretary- treasurer; W. W. Worthington, general manager; George Russell, superintendent; Bear Creek.

The Mack Mines.

Owned and operated by C. C. Mack, Big Sandy.

The Mace Mines.

Owned and operated by Thomas Philips, Maiden.

THE RED LODGE DISASTER.

The greatest disaster occurring in the coal mining history of the state was that of June 7th, 1906, at the Red Lodge mines of the Northwestern Improvement company, when eight men lost their lives as a result of attempting to approach a mine fire for the purpose of extinguishing or controlling it, and a subsequent effort at rescue.

Those of the fire fighters who lost their lives were Mr. Terrence Fleming, Mr. William Bailey, Mr. Michael Garriage, Mr. Thomas Skelly, Mr. Alvin McFate, Mr. Matt Reikka; and those of the rescuers who, in the attempt to save the lives of their comrades forfeited their own, were Mr. Roy Carey and Mr. Joseph Bracey.

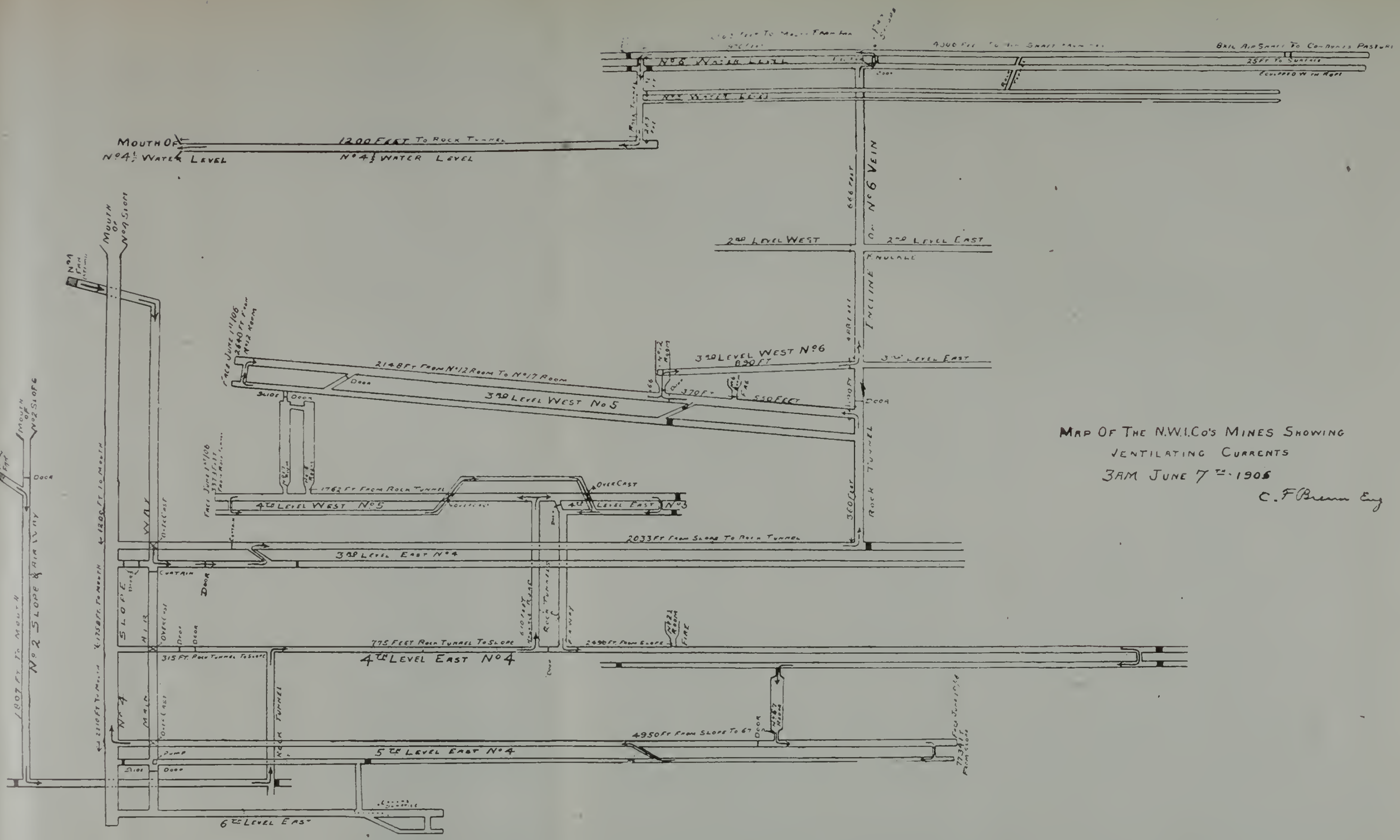
Aside from these fatalities there were many prostrations and many narrow escapes, and much heroism was displayed by the rescuers in effective rescue work and in futile attempts to save those known to be lying helplessly in an atmosphere laden with deadly gas.

The scenes at the mines, as mothers, wives and sisters gathered about the entrance anxiously awaiting the appearance or news of those for whom they so anxiously watched and inquired, was tragic in the extreme, and will not be forgotten by those who were present.

The State Coal Mine Inspector happened to be in Red Lodge at the time of the disaster and witnessed the scenes of terrible anxiety and the display of voluntary bravery exhibited in the persistent efforts at rescue.

At the time of the disaster, two fires originating from spontaneous combustion had been burning for some time. One of the fires was in Room 22, Fourth east entry, Vein No. 4; but the fire that cost the lives of the eight men was that of Room 6, Third west entry, Vein No. 5, the two fires being entirely unrelated, and each being on a separate current of air.

During the night of the 6th there was a crew of men fighting the fire in Room 22, and another crew performing the same service in Room No. 6. Toward morning on the 7th the fire in the latter room was gaining headway and part of the crew was called from Room 22 to assist those at Room 6, who were attacking the fire from the Third level Vein No. 5. At about 5:45



Map Showing the Direction of the Air Currents and Location of the Fires.

Those fighting the fire on the Fourth East Entry in No. 4 Vein, were supplied with air current from No. 2 fan, which forced air down No. 2 slope then through level entry to a rock entry that connects No.'s 2 and 4 veins and same current is directed to the Fourth West and Fourth East, in No. 5 vein, which entries are connected by a pair of parallel rock tunnels driven from the Fourth East Entry in No. 4 vein.

The air returns out the companion rock tunnel is conducted to the face of the Fourth East entry in 4 vein and out the back entry of Fourth East in 4, to 67 room—which is driven up from Fifth East Entry in 4 vein to the Fourth East entry—thence conducted to the face of the Fifth East Entry, and out the back entry to a point outside of No. 67 room, where it again travels on the main entry out to and up No. 4 slope to the surface.

On the night of the 6th of June, 1906, and up to 3 A. M. June 7, air was being supplied from No. 4 fan. The current being diverted from the back entry of No. 4 slope below the back entry of 3rd East Entry of No. 4 vein, by a curtain being hung across the back entry of the slope.

The door located on the back entry of 3rd East Entry being open, and the air traveled through a slant entry that connected the back and main entry of the 3rd East Entries. A curtain was hung on the main entry, 3rd East to prevent the air going out to the slope. The air was then conducted through a rock tunnel which is located about 2,000 ft. from No. 4 slope, thence to 3rd level West in No. 5 vein in the main entry to the slant that is driven to the back entry and in to the face of the back entry and out the main entry to No. 12, room in which the two veins are connected, No.'s 5 and 6, and thence out the 3rd level West No. 6 vein to the No. 6 incline on No. 6 vein through the fan (which was not running) thence out No. 6 water level to rock tunnel that connects No. 6 with the 4½ water level and thence to the surface.

MAP OF THE N.W.I.Co's MINES SHOWING
VENTILATING CURRENTS
3AM JUNE 7 TH. 1906
C. F Brenn Eng

ERRATA.

Page 99, 16th line, the words "in a line" should be "incline."

Page 103, 6th line from the bottom. the word "ebbing" should read "being."

The last line of page 104, "2 to 4" should read ".2 to .4."

The fifth line from the top of page 155 should read "2CO" instead of "2CC."

The sentence near the bottom of page 156 commencing "Even after persons," etc., should read: "Even after persons have been a long time in the atmosphere of this kind, they still may be rescued if they are made to breathe fresh air, or better still, pure oxygen, in order to enable the blood to free itself of gas."

Third paragraph, 8th line, second word, J. T. Beard's letter, should be "varying."

A LIQUID AIR RESCUE APPARATUS.

After some years of investigation by Mr. Otto Simonis, he has perfected the Aerolith, a liquid-air rescue apparatus, which weighs about 14 pounds, is easily carried on the back without any encumbrance, and gives an absolutely pure and deliciously cool air supply for up to 3 hours' working. It does not contain any chemicals; it is without any complications whatsoever; there is not a single valve in the whole appartus; and its use does not require any special training.

Atmospheric air liquefies at a temperature of —191 degrees C., and is compressed to about the seven-hundredth to eight-hundredth part of its original volume. Consequently 1 gallon of liquid air will evaporate into 700 to 800 gallons of atmospheric air. This principle has been applied to serve the following purpose:

A solid nickel receptacle, well insulated against atmospheric influence, capable of absorbing 1 gallon of liquid air in its asbestos-wool packing, is carried as a knapsack. A face mask, or a miner's mouthpiece, is connected through a double tube connection with this vessel; one tube leading in a diagonal direction through the vessel and thence leading into a double bag at the back of this vessel, serves for the air exhaled, which gives all its heat to the liquid air contained in the vessel, and so evaporates it; and from the top of the liquid air vessel the air evaporated is led through the other tube to the mouthpiece. The second bag is fitted with an outlet for the exhaled air, mixed with any superfluous fresh air at overpressure.

Liquid air can be stored in the vacuum vessels designed by Sir James Dewar, and will then, under ordinary atmospheric conditions, not lose more than 5 to 10 per cent by evaporation per day. Even at the present moment, when no purely commercial use for liquid air has been universally adopted, it can be purchased for 5s. ($1.25) per gallon; whereas it can be produced by small plants at 1s. (25 cents) per gallon, and by large plants at 6d. (12½ cents); 3d (6 1-4 cents) or even less per gallon. Liquid air can be transported with absolute safety by rail or car. For central rescue stations or large coal mines, however, it would certainly be desirable to erect an air liquefying plant. A plant, requiring about 8 h. p., producing about 1 gallon of liquid air per day and not occupying more than about 45 square feet, can be bought for about 400 pounds ($2,000).

One of the appliances has been purchased by the British Royal Commission on Safety in Mines for detailed experiments and research, and a large liquid air plant has been erected at Baron de Rothschild's coal mines in Austria, the Aerolith apparatus being substituted for all the latest types of mining rescue appliances heretofore used.

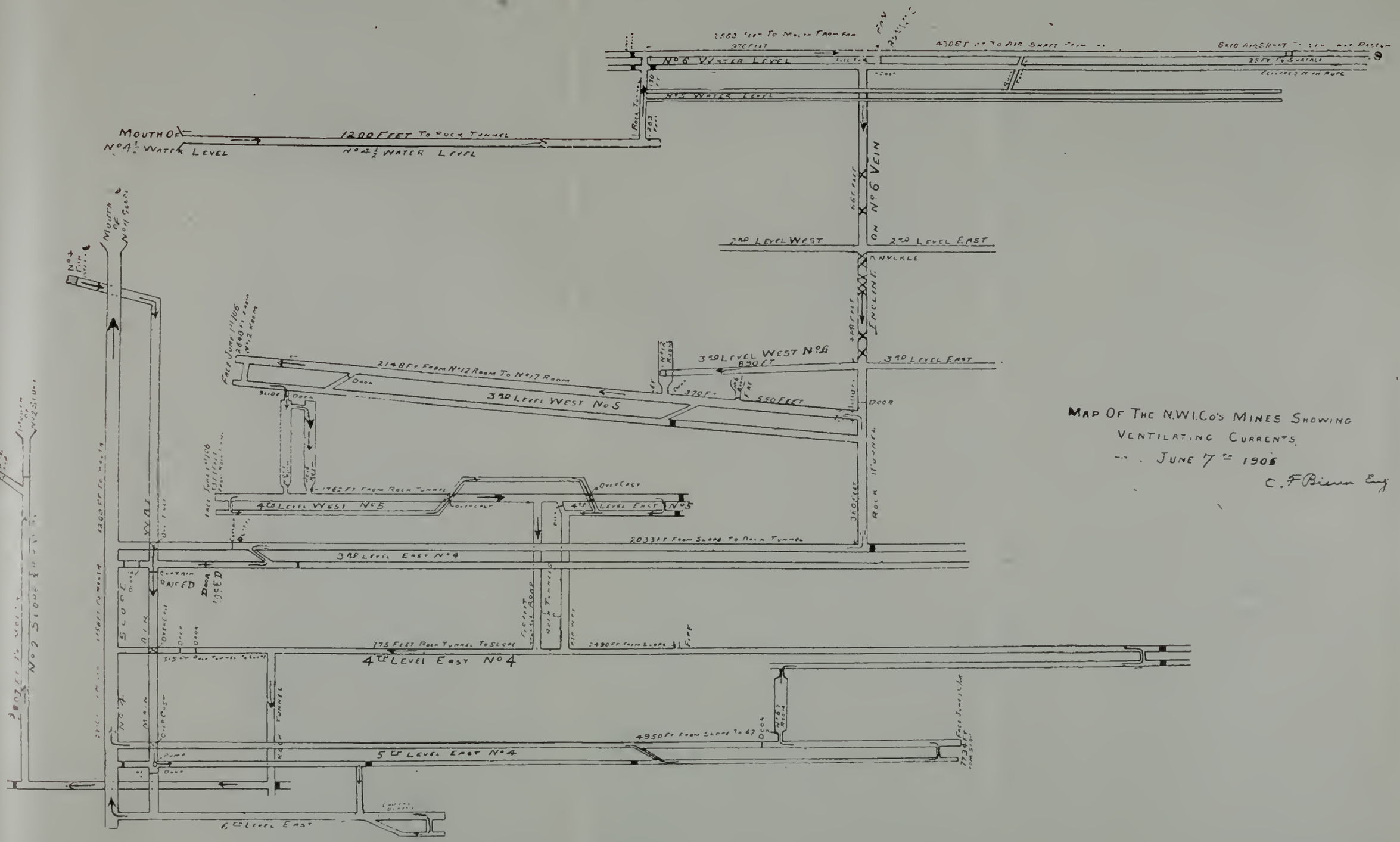
(The above is inserted for the purpose of calling attention to the possibilities of using liquified air instead of oxygen or compressed air.)

the morning of the 7th, those attacking the fire at this point determined to attack it from the opposite side, and with this intention went to the surface and entered No. 4½ water level, went through the rock tunnel and along No. 6 water level to the electric fan located at the intersection of this level and No. 6 incline. At this time the firefighters were supplied with an air current from No. 4 fan, located on the surface at the head of No. 4 slope, which was taken in from the back entry of No. 4, a curtain being hung on the back entry of No. 4 slope just below the back entry of Third east entry; the door was opened in the back entry of the Third east entry and the curtain hung on the Third east main entry outside of the crosscut, through which the current of air was taken into Third east entry and through the rock tunnel that connects the Third east entry in No. 4 vein with the Third east and Third west entry in No. 5 vein, and which also connects No. 6 in a line at the intersection of No. 6 incline and No. 6 water level, where No. 6 electric fan is located. This fan was not running while No. 4 current was being conducted through this part of the workings, the incline being used as the return airway. No. 6 water level is connected with No. 4½ water level by a rock tunnel, and this current had necessarily filled these levels and all the entries opening from the incline, with the smoke and poisonous fumes that were carried from the fire zone during the night of the 6th and until 5:45 the morning of the 7th. Before leaving to go to the electric fan, with the intention of starting it, the curtain was raised on the back entry of No. 4 slope and the door in Third east back entry was closed and the curtain in the Third east main entry was raised, which had the effect of conducting the current from No. 4 fan down the back entry of No. 4 slope to the face of the Sixth east entry and out and up No. 4 slope to the surface. The night crew that had gone down to the electric fan, which had not been running, the incline having been acting as an upcast, intending to reverse the diretcion of the intake air current, so as to enable them to go down the incline and into the Third west level of No. 6, to the opposite side of the fire in room No. 6, started the fan as a force. The starting of No. 6 (electric) fan had the effect of forcing the air down the incline, No. 4½ water level and the air shaft in No. 6 water level acting as intakes. The air passing down the incline, by the closed door at the inter-

section of the rock tunnel and No. 6 incline, was diverted into Third level west No. 6 vein, passing through No. 12 room that connects Third level west of No. 6, with Third level west of No. 5 vein, the veins coming close together at this point, into the face of Third level west in No. 5 vein, out the back entry to the rock tunnel and through the tunnel to Third level east in No. 4 vein, to No. 4 slope and out to the surface. The men found the air in the incline so pregnant with gas that they decided to retreat. On counting their number, it was found that one had started out toward No. 4½ water level, and Mr. Haggerty started after him. The balance of the crew started out the level in the opposite direction and finally reached the surface through the air shaft. Mr. Haggerty found the man overcome and at the same time was himself prostrated. As the fan was running and the water level was acting as an intake, the air was becoming purer and both men revived and in a short time effected their escape and went to the company office. After the arrival at the office of the two men who had barely escaped with their lives through No. 4½ water level, the day crew consisting of thirteen men, was allowed to enter the level in an endeavor to reach the point at which it had been determined to attack the fire. On reaching No. 6 incline, the men strung out along the incline, some being a considerable distance ahead of those behind. Before reaching the Third west level that branches from the incline, the men became aware of the dangerous condition of the atmosphere and attempted to retreat. Those of the crew that started to make their escape through the air shaft of No. 6 water level selected the two most physically able and had them hasten ahead and notify the office of the dangerous condition of the mine air and of the fact that two men, if they had not escaped, would be found along the other end of the level, and that if the rest of them did not get out through the air shaft, to send them assistance. The word reached the office, but not until after the day crew had gone into the mine through No. 4½ water level, and down into the incline. On receiving this information, Mr. Pettigrew, Mr. Sells, the inspector and others immediately secured lamps and went down No. 4½ water level to the electric fan where they found Mr. Chambers, and he was sent down the incline to reconoiter. He returned in a few moments, in an exhausted condition and reported seeing

three lights on the incline. A few moments later Mr. James Fleming, Mr. Sam Newman and Mr. Dan Sutherland, of the day shift, came up the incline and through the fan. They were all much exhausted, verging on a state of complete collapse. They said that it would be impossible for a man to live on the incline, and it was suggested that if those of the others of the day shift who had gone down the incline could not make it from No. 12 room to the fire at No. 6 room, that they would endeavor to escape through the slide door at No. 17 room, which connects Third west entry in No. 5 vein with Fourth west entry in No. 5 vein. Acting on this suggestion, the rescuing party went out to the office, rigged up safety lamps, had a considerable increase in the party and went down No. 2 slope and through a rock tunnel that connects the level in No. 2 with Fourth east entry in No. 4 vein, through rock tunnel to Fourth west entry in No. 5 vein, up room 16 and through the crosscut into room 17. All the party except Mr. Pettigrew, the general superintendent of the Northwestern Improvement company, and Mr. White, the fireboss, were instructed to keep behind and to keep below a bench left at the top of room 17. Upon examination it was found the CO_2 (black damp) filled the back entry of Third west in No. 5, the lights being extinguished. While the party was at this point, a messenger was sent from the outside to tell the rescuing party to come out immediately, that the men were in the No. 6 incline, two of the remaining ten, Mr. Joe Woods and Mr. Matt. Kintalla, having crawled out without assistance. Upon reaching the top of No. 2 slope, a consultation was held, and Mr. Haggerty, the mine foreman who had been previously overcome and revived, ordered the slide door in room 17 opened, and No. 2 fan reversed, the object being to make No. 2 fan an exhaust, instead of a force fan, and assist the No. 6 electric fan. The electric fan was forcing air down the incline, and by opening the slide door in room 17 and reversing No. 2 fan, No. 6 would be forcing and No. 2 drawing on the same current. Mr. Sell, Mr. Fred Willey, Mr. James Creighton, the inspector and several others, went down No. 2 slope and opened the slide door in room 17. In the meantime Mr. White, the fire boss, and others went down No. 4½ water level and the former ordered the electric fan stopped. Those accompanying and Mr. White made an attempt to save those lying along the incline. It was a brave,

but fruitless attempt, and a number of the rescuers were overcome by the gases, quickly becoming unconscious, and had to be speedily removed by those who had remained in the less vitiated air. Those who had gone done the No. 2 slope to open the door, returned to the surface and immediately went in No. 4½ water level and an attempt was made to start the electric fan that had been closed down, but for some reason the fan would not work and it took some time before it could be started. When the fan was started, it was allowed to run for about three-fourths of an hour before the organized rescue party attempted to go down the incline. On going down the incline, Mr. Thomas Atherton was found lying at a distance of about three hundred and fifty feet from the fan, and two members of the first rescue party and eight men of the day shift were found lying on the floor at different points further down the incline. These men were all removed to the surface as quickly as possible and two of the day shift, Mr. William Tarling and Mr. H. L. Bolyard, were finally resuscitated. The others were dead when removed from the mine. The appearance of those who were dead, and the evidences of those resuscitated, clearly evidenced poisoning and asphyxiation by carbon monoxide. The changing of the current of air, i. e., exhausting air past the fire and out and up the incline, filling the passages and old workings with the fumes from the burning coal and wood, during the night of June 6 and to between five and six o'clock of the morning of the 7th, and then starting the No. 6 fan as a force, withdrew the stored gases and forced them down the incline and back into the Third west level of No. 6 vein, and the attempt to enter the incline so soon after the reversal of the current, was, in my judgment, a grave error. The miners should not have been allowed to enter the mine; no one should have been allowed to enter the mine, except to perform such duties as might have been necessary to remedy the condition, and then there should have been proper protective preparation and a full knowledge of the dangers to be encountered. When the condition of the air was discovered by the fire boss—at the time the night shift was at the fan for the purpose of starting it, and when they found they could not proceed down the incline with safety, noting the presence of white damp—he should have posted on the door of the fan, "Danger, Keep Out!" Neither should No. 6 fan have been ordered stopped when it was, as the purpose of reversing No. 2



Map Showing Object of Opening the Slide Door in No. 17 Room, and Reversing No. 2 Fan.
The Stars on the No. 6 Incline Approximately Indicate the Location of the Bodies

fan and opening the slide door in room 17 was to enable No. 2 and No. 6 fans to assist each other, in supplying pure air to that portion of the mine. There had been numerous fires at the Red Lodge mines, but up to this time there had not been any serious results coming from them, and the danger arising from the deadly gases being constantly generated, was not appreciated by those encountering them. Neither the management or any of the employes anticipated serious results. Considering the fact that CO is always present after powder explosions and invariably impregnates the air with large percentages during and after a mine fire, the percentage of mining men and miners who know anything of this insidious gas and its deadly effect, is surprisingly small.

Since the disaster at Red Lodge, the department has made an effort to collect the experiences of practical mining men and the knowledge of professional men who have made the subject an especial study, and present them in this report, so that the coal mining men and the coal miners, those who are directly involved, may be given all possible information relative especially to carbon monoxide, to add to the knowledge they may already possess in the premises.

The gases which arise from the decay of vegetable matter, were, in the formation of coal, necessarily imprisoned in the seams, and these are the marsh and other gases expected and naturally encountered in our coal mines these gases, stored in the crevases and pores of the coal, being gradually forced by expansion through the escapes offering the least resistance and in so doing readily find their way into the workings of the mines. These occluded gases must be distinguished from the gases that enter into the chemical composition of the coal, and their transpiration from the solid coal is caused by the pressure with which they are pent up. These gases diffuse or mix with one another inversely as the square root of their densities, the lighter gases mingling the most readily in the surrounding atmosphere. Marsh gas, ebbing the lighter, will diffuse more rapidly with the fresh air passing through the workings of a mine, than will the more heavy carbonic acid gas. Gases are constantly travelling in all directions and communciating with each other, as they are never at rest and their diffusion is mutual. And while the diffusion of the gases

of a mine is made more rapid by the removal of tainted air and the substitution of fresh air introduced with some velocity, the mutual and natural diffusion is always going on in some degree. The fact that marsh gas accumulates near the roof of a gallery or heading is not because there is no diffusion, but because the transpiration occurs from the immediate coal strata and is in greater volume than can be directly diffused or carried off by the ventilating currents; and in all instances of such accumulation, there is either a deficiency of ventilation or an unusual transpiration of gas. Where upheavals occurred or there have have other changes in the stratification that caused the sinking of the coal measure and the seams at the edge of the basin have been exposed, the gases have been afforded an opportunity to escape and the gas pressure in the coal will have been greatly reduced, even to great depth, and in some cases will have wholly disappeared. Where the gases have not been liberated in this way, the working of the coal in the ordinary way, exposes the surface and allows the liberation of the gases, and the mining of the coal adds to the production; so that not only are the stored gases set at liberty, but the admission of air to the coal the latter is so acted upon as to create a not inconsiderable supply of other gases.

THE INQUIRY MADE.

Office of the Inspector of Coal mines.
Helena, Montana.

July 7th, 1906.

Dear Sir:

For the purpose of obtaining the experience of practical and professional men with CO (carbonic oxide), and of ascertaining a safe and sensitive means of determining its presence in the mine, the detectible and fatal percentages, I am addressing the inquiries to a number of persons throughout the country who are prominent in the supervision of this line of industry or study.

Owing to the very small percentage of CO (white damp) that is fatal, the making of tests is extremely dangerous, and I will venture the personal opinion that it is unsafe to experiment or test with an ordinary safety lamp, as, according to many authorities from 2 to 4 per cent is dangerous, and some authorities

claim that ½ of 1 per cent in the atmosphere of a mine will cause death by poisoning, while others range higher in percentages, going as high as 25, which, however, I am satisfied is entirely too high.

Some writers claim there is no taste, color or odor to carbonic oxide, but it is a fact that mine fires produce a creosotic odor and with it the presence of carbonic oxide is expected, being generated by the combustion of coal or wood in the mine, also, CO_2 coming in contact with incandescent carbon (carbon at white heat) generates CO.

If moved by a powerful current and some of the CO finds its way into old workings would the gas in, say one month or a longer period, have its fatal qualities dissipated? What is the best means of determining the presence of CO in such old workings? What experience and results have you had in making tests with birds, mice, etc? What percentage of the oxide is necessary to cause the death of birds, mice or other animals? The hydrogen flame and the blood tests are advocated, and if you have employed them, I would like to receive your results.

What effects have you noticed on the respiratory organs of mice or birds used in tests, or more particularly on men who have come in contact with the gas?

Respectfully yours,

J. B. McDERMOTT,
Coal Mine Inspector.

REPLIES RECEIVED.

In response to the foregoing letter of inquiry, I have received the following replies, all of which are interesting as touching matter pertinent to the premises, and some contain distinctly valuable and practical information:

Department of Mines,
State of West Virginia.

James W. Paul,
Chief Mine Inspector.
Charleston, August 22, 1906.

Dear Sir:

I have the honor to reply to your letter of the 7th ult., in which you inclose a series of questions relative to carbon monoxide gas in its relation to coal mines, the methods of detecting

any changes the gas may undergo when allowed to remain within the workings of a mine, etc.

You are deserving of special commendation for the work you have undertaken in an effort to collect data upon this subject, which is of such vital importance to the safety of life within the mines, and I hope you may be able to publish your deduction in order that the mining fraternity may have the benefit of your research.

In West Virginia there have been a number of mine explosions in which a great loss of life has resulted and it is the opinion of the writer that a large percentage of the deaths have been due to carbon monoxide poisoning.

In investigating a number of explosions within the mines, I have requested the attending physician to make a test of the blood of the dead, but so far I have failed to find a company physician who had the facilities, and in a number of cases the physician apparently had no knowledge of the details of making the simple blood test.

In exploring the mines after an explosion, I have never failed to detect an odor and which appears to be peculiar to all mines in which an explosion has occurred; but as yet I have been unable to describe this odor, since it is so different from any other, with the cause of which I am familiar.

I have found that men are unable to remain long in an atmosphere loaded with this peculiar odor, although a safety lamp burns well in it and shows no cap on the flame.

I have never experimented with mice. I long since adopted an infallible rule: never to go ahead of the fresh air while exploring a mine effected with an explosion.

As to tests for CO gas, I believe it would be practicable to carry into the mine a quantity of normal solution of blood from which small quantities may be drawn and by means of a small air pump a given quantity of the mine air could be forced through the normal solution and the reaction observed. Detecting the mere presence of the gas would be sufficient to warrant the explorers in withdrawing from that part of the mine.

As to CO gas changing its composition upon long contact with fresh air and taking on another atom of O and becoming CO-2 gas—I have serious doubts if such reaction would take place in the absence of a flame or red heat. To change from CO to CO-2, we would have 2CO plus 2CO-2.

I do not believe that CO gas would undergo a slow process of oxidation such as we have with some of the base metals, consequently I would not see any reason why CO gas in any unventilated part of a mine would change its chemical form.

Trusting that I have fully complied with your request, I beg to be, Yours respectfully,

JAMES W. PAUL,
Chief Mine Inspector, West Va.

Corona Coal & Iron Company. Mines at—

Corona
Patton
Coal Valley
Lockhart

Dora, Alabama, July 22, 1906.

Dear Sir:

Yours of the 7th inst. is received and contents noted, and in reply will say: Concerning CO (carbonic oxide), I have been especially fortunate, as I have been in charge of mines as Bank Boss and superintendent, and have come in contact with but little of the gas.

The only way I know to detect the gas is by the flames of a lamp, as the gas is odorless and tasteless. It would be hard to ascertain the exact per cent, or the minimum percentage, that will cause death. The only method I have been willing to adopt, where I suspected the slightest presence of the gas, is to so increase the air current as to certainly render it harmless before letting men go into it. I would not care to go into the gas in order to make tests.

Yours respectfully
N. G. MATHEWS.

Commonwealth of Pennsylvania,
Twelfth Bituminous Inspection District,
Roger Hampson, Inspector.

Punxsutawney, Pa., July 25, 1906.

Dear Sir:

In answer to your favor relative to CO, will say that I have had very little experience with it; in fact, only once, and that was in a part of a mine near where a furnace had set fire to the coal, and my attention was called to the probable presence of

the gas by the complaint of some men who were working in the vicinity and who stated that they felt strangely. On investigating, I found that just beyond the last crosscut the light would burn brightly and at the same time I could feel the presence of CO in the atmosphere. I had the men taken out and a current of air turned through that part of the workings, and did not hear further of the matter.

No, I believe the death-dealing qualities of the air will be present, as, in the case above recited, it was months after the fire had been put out that I discovered the presence of the gas, and I believe that when it is carried into old workings that it will be a danger for quite a while.

I do not know of any safe or accurate test other than the light and feeling the effects, and in the case I have observed, the percentage must have been very small, otherwise it would have exploded from the flame of the open light; but I had no means of ascertaining what percentage was really present.

Respectfully yours,

R. HAMPSON,

Sunday Creek Company.

Athens, Ohio, July 30th, 1906.

Dear Sir:

Replying to your favor of the 9th inst., re the detection of and my experience with CO (carbonic oxide), must state that I do not believe that 2 per cent or 4 per cent is dangerous for a short time. It would, were a person to breathe it day after day, have some effect on human life, just the same as a comparative quantity of any other narcotic.

Incident to a blast of powder in coal in a mine, there is nearly always a production of CO because of the incomplete combustion of the explosive compound. It is a common thing to see the gas burn near the location of the blast, especially when the charge has been too great.

Eminent authorities state that with the exception of hydrogen gas, CO has the widest explosive range of any known gas, being violently explosive when diffused with air of 1 6-10 to 6 7-10 in volume,—61.5 to 87 per cent air. This being the case, there must be at least 10 per cent of it to burn as above. Were there some device that would show the actual amount of this gas, after

firing a shot in a working place with poor ventilation, I am confident it would show from 2 to 4 per cent of CO. From the generation of this gas as above, there is no odor; and in the case of mine fires, I think the creosotic odor is a production of the mine fire and not a property of CO. From comparison I do not understand how there could be any smell.

When the gases of different densities are exposed to each other they diffuse with a speed in proportion to the difference in their densities until they are mixed in equal proportions—hence, if CO is lodged in old, unventilated workings, the CO generated there will diffuse with it, and the result will be, I should say, CO_2—carbonic acid gas. I believe the truth of this statement is borne out by the fact that even where a mine fire is known to generate CO, if the supply of air is cut off from the outside by covering the shaft, the result occurs as above.

I have under my supervision, a mine where these conditions exist.

I have read of tests made with birds, mice, etc., but as nothing like this has ever come under my personal observation, I would not care to venture an opinion.

On account of the fact that mines under ordinary conditions do not secrete CO in large quantities, and where it does occur in large quantities it would not be safe to test it, I have not applied much thought to the perfection of any testing apparatus that would indicate percentages of the gas.

With best wishes for success in this line, I remain

Very respectfully,

D. H. WILLIAMS,
Dist. Sup. Sunday Creek Co.

International Correspondence School,
J. T. Beard, Principal School of Mines (Coal Mining Division), and Associate Editor Mines and Minerals.

Scranton, Pa., July 24th, 1906.

Dear Sir:

Blood test is good, but mouse test is more reliable. Mouse carried in open cage will stagger and fall twenty minutes before men are affected.

Very truly,

J. T. BEARD.

NOTE—This was in reply to special inquiry.

State of Iowa
Office of Inspector of Mines, District No. 1.
John Verner, Inspector.

Chariton, Iowa, July 14th, 1906.

Dear Sir:

Your letter relating to CO has been receved.

I have not the time to take the question up in detail, but in a general way will say that CO as generally found in the mines is due (1) to the use of powder (2) to mine fires in unventilated parts of the mine, (3) to explosions in which dust is an important factor. I have also discovered the gas in mines where none of the above conditions existed, but in these cases the amount was very small and readily discernible by the flame of a naked light. No safety lamp or other device is needed, in my judgment, to establish the presence of CO. If the naked light is not safe to use, the safety lamp is not, nor is any other gas device. For practical purposes laboratory tests and results are of little use. Except in case of mine fires there is little danger of loss of life by carbon monoxide, if proper care is taken. If the fact is appreciated scufficiently, that CO may be encountered, and a person is on the lookout, the danger line will not be crossed. We have no CH_4 in the Iowa mines, but we have some CO. The lamp tests I have found reliable and safe. Should the gas be present in explosive quantities and be entered by a person, in my judgment that person will die in it, even if it should not explode. In conjunction with the lamp test, the actions of the human body will reveal to the person of experience the presence of the gas. The breathing will become more labored and the heart beats will increase. This is also true where CO_2 is present, only it is not quite so marked in the latter case. Unless there is fire in the old workings, or unless the strata naturally produce CO in appreciable quantity, I do not see why there should be any danger on account of such old workings, or rather, the gases they may contain in the future. Of course, eliminate the presence of fire-damp. In case of much fire in old workings, even if apparently stopped off well, there may be danger of an explosion of CO, especially it a strong current of pure air is traveling alongside of the seat of the fire. The recent disastraus explosion in France is a case in point. In the absence of fire, and under ordinary mine conditions, the carbon monoxide pres-

ent in old workings will not harm anybody, in my judment, if ordinary care is used. Very truly,

JOHN VERNER.

Commonwealth of Pennsylvania.
Eighth Bituminous Inspection District.
Joseph Knapper, Inspector.

Philipsburg, Pa., July 28th, 1906.

Dear Sir:

Your letter of inquiry was received and contents carefully noted, and in reply will say. It is a hard proposition to answer, not for lack of knowledge of different conditions existing in the mines, but not being exactly sure of the mixture of gas encountered when observing lengthening of the flame, explosive mitxures ignited, or the action of men overcome in the mines—all because there is no test whereby we can accurately test samples of the mine atmosphere. It was the great problem on which Thomas Shaw of Philadelphia, who invented the mechanical test of mine atmosphere, spent years of his time, and when he got through he could only make samples of CO, and knowing their percentage, subject them to chemical tests in tubes, and that give him an idea that some particular samples of mine air contained a percentage of CO (carbonic oxide) without getting the amount or percentage contained therein. But he did prove beyond a doubt the action of small animals, such as mice, rats, rabbits and guineau pigs, in the presence of a percentage which he himself made. If I remember correctly he published an account of his observations, or his son-in-law did, after the former's death. The article was published in the Colliery Engineer some time near the year 1900. I do not distinctly remember the exact report at this time, but he said: "7.5 per cent make a violent explosion with only a resultant blue flame, if exposed to an open light, and makes a violent detonation in the 1" diameter glass tube, 6" long, which was used when ignited. Also, that small animals exposed to 2 per cent, under a glass jar, at once lost the power of their limbs, not exhibiting any contortions as indicating pain, and if not removed at once, soon expired, all respiration stopping after two minutes' time, and possibly after 10 minutes, pulsation ceased.

If CO should be driven into distant parts of an abandoned

mine, and was high in percentage, but was in the vicinity of water, part of the mixture would be absorbed by the water, reducing the mixture, and adding CO_2 instead. I have come in contact with mixtures in such places, which was observed by the lengthening of the open lamp flame to 7 and 8 inches high, with a fine spigot or needle shape from base to summit, and while I had no idea as to the percentage, I had a weakening of the lower limbs, causing slow motion or speed in walking. I can refer you to Samuel Fouty of Osceola Mills, who is mine foreman of the Gem mines, and who had such a condition in the mines at the time of my last visit, and who could not be persuaded to accompany me beyond a certain point down an old section stating that he could not walk any further; the lamp flame burned brighter than in an atmosphere of fresh air. At other times I have been where they were trying to put out mine fires by the direct method with fire engine and hose, and the man in charge of the hose was sitting down when I arrived at the mine, and on being asked what was the matter with him he did not answer, but others said he was tired and taking a rest; a minute later he could not speak, but sat down or reclined in a heap, and I ordered him carried out, finding that the man had become unconscious; yet our lamps were burning at least as brightly as usual. Another case was at Atlantic No. 1 of the Berwird White Coal Co. The company was sinking a shaft six feet in diameter to a coal seam below 50' deep, and when they left on Saturday evening a round of shots had been put off. On going down the shaft Monday morning the first man down could not answer the calls of men on top, and he commenced to sink slowly to the floor of the shaft, and it was with difficulty that the men on top could make a hurried descent and get the man in the bucket, before being similarly overcome: but the lights burned brightly.

In regard to the odor in mine fires, I do not think it comes from white damp (CO), but a pungent odor of sulphur and gas, with an oily smell distilled from the burning coal: because a complete combustion of the burning coal would scarcely give off carbonic oxide, but rather carbonic acid gas. The sulphur fumes deaden the smelling power of the nostrils, so that any other odor could not be detected under the conditions. I have noticed in some sections of a mine where a fire was burning,

that in putting a safety lamp in a cavity on the gob falls, an ignition of gas inside the gauze occurred; but as the mine generated CH_4, and a blue flame was observed, it was not possible under the conditions to determine what gas it was. As carbonic oxide has a specific gravity of .967, nearly the same as air, it can readily be all through the atmosphere of any section of the workings. I have observed it to burn with a bluish flame, immediately after heavy blasts have been put off in shaft sinking; and an old contractor named Dowie, of the Connellsville region, used to resort to sending a bundle of burning sticks down the shaft to consume the gas; and then we had no means of determining accurately if it was carbonic acid gas. I believe if a man goes gradually into atmosphere containing a small percentage of such gas, unless he suspects its presence and observees the lengthening of the lamp flame, the first symptoms following will be the weakening of the lower limbs, and if he does not retreat at once he will be deprived of the use of his limbs, nor will he be able to call for assistance as he will have been deprived of the power of speech, and yet for a time will hear what others are saying and will be conscious that an effort is being made to save him; but he will not be able to assist himself.

I could not give any results from the blood tests, as I have not made any experiments in the line.

Prior to being mine inspector, I had charge for two years of Shaw's mechanical test machine, and he gave me the title of Expert on Gas, but he never gave me a practical method of detecting carbonic oxide gas, but would have done so, if only for the purpose of advertising his machine.

In writing this reply I only give the practical experiences I have had, knowing that you can readily refer to books published on the subject, as I can.

I made numerous tests while in charge of Shaw's machine, upon the small animals you speak of, and also took the English sparrow and the house cat; but through most of my experiences with all gases, except with white damp, so much having been said of its deadly effect if breathed, I did not care to generate it with the crude appliances in my possession. If I can in any way give you additional data, I shall be pleased to do so.

Yours respectfully,

JOSEPH KNAPPER.

The above letter was not written for publication, but the liberty is taken with it. Replying to a letter of acknowledgment and the request that the above letter might be published, Mr. Knapper writes as follows:

"In support of my opinion, I must quote some authorities. I said where CO came in contact with water that it would not always remain stratified, but would be partly taken up by the water in solution, even if the water were charged with 100 per cent of carbonic acid gas (CO_2), especially if the water were disturbed and part of the CO given off. To quote Mr. Thomas Shaw, an expert of Philadilphia, now deceased: 'If a perfect rubber bag is filled with specified volume and percentage of CO, and even though the pressure was higher under which it was confined in the rubber bag, if it was tested in the evening for percentage and in a body of water, for volume, after standing 24 hours, the volume in a perfect bag would be the same, yet the percentage would be less; and if the bag had been standing immersed in water, the percentage would be still less and a proportionate, or rather, per cent of CO_2 take its place, in spite of the greater pressure in the bag than of the atmosphere; and he gave it the name 'misos' and 'exhosmore.' It often made me think it hardly possible that a gas at higher pressure in a bag would exchange volume and percentage of any surrounding gas or atmosphere at a lower pressure, but on explaining that the one had an affinity for the other, I was bound to accept his statement from the numerous tests he had made by combined mechanical and chemical processes. And referring to the case I wrote about, sinking a shaft where they encountered CO after 48 hours of rest from blasting; if CO always remained in that state, how did the men work without being similarly overcome, when they did not know the trouble or cause of it? None of the officials knew of the occurrence until that evening, and they had no mechanical means of removing the carbonic oxide. And now, in support of some of these statements: I looked up a book written by Augustus H. Gill, S. B. Ph. D., Professor of Gas Analysis, first edition, page 82. He says: 'One volume of water at 68 degrees F. and reduced to 32 degrees F., and 760 MM. pressure, absorbs 0.023 volumes of CO (carbonic oxide gas);
and the same absorbs .901 volumes of CO_2.
and the same absorbs .035 volumes methane (CH).

and the same absorbs .014 volumes nitrogen (N),
and the same absorbs .017 volumes air,
showing by his statement the methane is second and CO third greatest of soluble gases. He used centigrade temperature of 20 to 0 degrees. And looking over the Encyclopedia Britannica, page 87, vol. 5, he says it is sparingly soluble in water, giving it at 1-40th of its bulk at 15 degrees C. So that by referring to the two books, it shows CO once stratified in remote workings, must in time change in percentage, absorbing other gases and liberating part of its own, possibly more especially in contact with running water, so that the percentage at least would be reduced. And you know we are taught by the text books that all gases diffuse according to the square root of their density. The books just referred to also state that when a mixture of equal volumes of carbonic oxide and chlorine gas are exposed to the sunlight, the two gases combine, forming chlo-carbonic oxide or phosgene gas—COCL. I am not fully familiar with the last mixture, but quote the book to show they change. I made numerous tests with all other gases on animals until they were overcome, and had a preparation of clay to bury in to prove that old theory it is a means of bringing them to, and I tried one of the animals exposed at the same time in the same percentage and volume of gas, under a stream of running water, and in nine out of ten rats, the one under the spray of water came to and lived, while those in clay prepared for the purpose, died. This result may have been owing to the solubility of the gas in water; or else, agitation caused restoration of breathing. I believe that plenty of fresh air or in the vicinity of running water either pouring down a solid sinking, or running through the old workings in proximity of the CO, it is bound to move. How could we ascend in a balloon and penetrate the CO that is constantly given off by the mills and coke ovens, if it stratified and remained?

Very respectfully,

J. KNAPPER.

Secretary of State,
Home Department.

Whitehall, London, S. W., July 24th, 1906.

Dear Sir:

With reference to your letter of the 7th inst., I regret that personally I do not possess experience in testing the gas you desire

to know about, but I take much pleasure in sending you, under separate cover, a copy of Dr. John Haldane's report to the secretary of state, on the causes of death in colliery explosions, and also a report by the late C. Le Neve Foster and Dr. Miller, into the circumstances of an underground fire at the Snaefell lead mine.

I have sent your letters to the following inspectors of mines in this country, and asked them to write you direct.

R. McLauren, 19 Morning Side Park, Edinburgh, Scotland.

J. B. Atkinson, 2 Devonshire Terrace, Newcastle-on-Tyne.

John Gerrard Worsley, Manchester, England.

W. N. Atkinson, Barlston, Stoke-on-Trent.

F. A. Gray, 7 Victoria Square, Penarth near Cardiff.

Joseph S. Martin, The Vikings, Durham Park, Bristol.

I would also refer you to the recent work of "The Investigation of Mine Air," by Sir C. Le Neve Foster and Dr. Haldane, published by Chas. Griffin & Co., London, copies of which can be secured from the Engineering & Mining Journal, 505 Pearl street, New York City.

I hope the above will be of some service to you. I am, dear sir, yours very truly,

W. W. WARE.

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19 Morningside Park,
Edinburgh.

3d of July, 1906.

Dear Sir:

The home office authorities have asked me to write you on CO, and I enclose herewith a few notes. It would take up too much of my time to discuss all of the points of your letter, but I have noted for your information a few things which may be of use to you. A safety lamp never indicates the gas, and as far as explosions are concerned, you will not have such under ordinary circumstances with a naked light in an airway.

Yours faithfully,

ROBERT McLAREN.

The following is Mr. McLaren's paper:

Carbon Monoxide—CO. This gas is a product of incomplete combustion and is invariably associated with underground fires and explosions of fire damp and coal dust. Happily, in my dis-

trict, the latter seldom takes place; but the gas is well known in some seams of coal which fire spontaneously, and in these seams the fires are first discovered by a smell resembling parafine oil, locally called "coal stink." The principal element in the origin of the fire seems to be sulphur or due to pyrites in the coal or roof or places above. A practical example of this occurred about two months ago in a seam of coal where stoping for the first time had only recently begun. A slight, unusual odor was detected by the officials, but as they had not had any experience in underground fires, litte heed was paid to it until a workman hanging on tubs at the foot of an incline, where the return air from stoping passed, fell unconscious. The manager telephoned to me, and after hearing particulars, suggested putting down some new silver coins, etc., in the airway, and the result was that the gas proved to be SH_2. Next morning I went to the place, and while there was a slight smell of SH_2, the odor of "coal stink" was distinct, and I had no hesitation in deciding that a fire was in progress, and so it turned out, and the section was built off. My experience has been greater in connection with underground fires and CO, from them, than most inspectors, as, in addition to having suffered from its effects in leading rescue parties, a number of lives have been lost through it in this district. Except the "stink," which may be mixed with air so as not to be deadly, there are no practical means of readily detecting the gas. I have found that birds (canaries preferred), are the most sensitive to the presence of the gas, and in conducting operations for the recovery of bodies I adopt certain precautions, as: two men upon whom I can rely are selected to go in front carrying the birds, and as soon as the birds show signs of collapse, the men retreat. No one is allowed, except the men in charge of the birds, to go in advance of the fresh air—taken in by means of brattices—and on no account is any one allowed to be on the return side. The rescue apparatus, such as the Shawnek or Gasporth types, will be useful in going into a mixture of gas in rescue work or in building off stopings.

In reference as to whether CO loses its properties after a time, say a year, the question may be answered by an accident that occurred here three months ago. A fire broke out twelve years ago, and the gas escaped recently, and two lives were lost. The same thing happened seven years ago, when seven men were killed.

I have not gone into the scientific side which would involve too much time, but will say that the temperatures play a large part in forming and reforming CO and CO2.

ROBERT McLAREN,
H. M. Inspector of Mines, East Scotland District.

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2 Levonshire Terrace,
Newcastle-on-Tyne.

30th of July, 1906

Dear Sir:

Mr. Ware of the home office has forwarded your letter of the 7th inst., relating to CO. I have had some experience as to the presence of CO in collieries after explosions (principally due to coal dust), and after spontaneous fires. I have been present after explosions when persons were overcome with some gas, probably CO, which did not indicate its presence on the light of the safety lamps or in any other way.

As to how CO would be affected by the lapse of time, or whether it would oxidize to CO2, I have no knowledge. At collieries at Fife, where spontaneous fires are common, mice and small birds have been used to indicate the presence of CO, successfully—that is, in exploring in the neighborhood of the fire, the mice or birds have collapsed before the persons present felt any ill effects, and this acted as a warning.

Platinum perchloride on paper, is a test; but I have not known it to be used with advantage. I imagine that where sufficient CO is present to show on the flame of any lamp, a man could not live long. I have not had any experience with the blood test. I have never known CO present any length of time after an explosion or fire.

Yours faithfully,

J. B. ATKINSON.

Barlston,
Stoke-on-Trent.

July 25th, 1906.

Dear Sir:

Mr. Ware of the home office has sent me your letter of the 7th inst. on the subject of carbon monoxide in mines. * * * Under separate cover, I have the pleasure of sending you a copy of my annual report for last year, in which the subject is re-

ferred to. With reference to your question about CO in unventilated workings, I do not know that any lapse of time will render the CO non-poisonous; but it might be dissipated by diffusion. I would not consider it safe to enter such workings, even after a long period, without the precaution of taking a mouse or having the air analyzed.

Yours faithfully,

W. N. ATKINSON.

Civil and Mining Engineer,
Member Board of Mine Examiners.

Des Moines, Ia., July 16th, 1906.

Dear Sir:

In reply to yours of the 7th inst., will state that my experience with carbonic oxide has been limited, as there is but a limited amount of it found in the Iowa mines. All my experiments have been with Prof. Floyd Davis, of this city, and I have referred your letter to him, and I am sure you will get some very valuable information from him.

Very truly yours,

JOE W. BAKER.

Galloway Coal Company,
Exclusive Miners of Elk River, Galloway and Garnsey Coal.
James Nicol, Superintendent.

Galloway, Ala., July 16th, 1906.

Dear Sir:

Yours of the 7th inst. to hand, but must say that I have never had any direct experience while I have been mine superintendent, with CO. I most certainly believe that a strong current of air will be necessary to make the workings invested with white damp, safe for human life; and as long as this air is applied, there will be no danger from white damp.

Yours truly,

JAMES NICOL.

Office of the Board of Examiners,
Coal Mine Managers,

Nanaimo, B. C., July 25th, 1906.

Dear Sir:

I enclose capies of letters from Mr. J. B. McDermott, Inspector of Coal Mines for the State of Montana, and from W. F. Robertson, Provincial Mineralogist. They are self-explanatory, and agreeable to the requests contained therein, I shall esteem it a favor if you will give Mr. McDermott the benefit of your experience with carbonic oxide, or the result of any original search with the gas.

You will understand from Mr. McDermott's letter that he is in search of other than text book information, and as the replies will no doubt contain information which will be of value to our own Mines Department, I will thank you to favor me with your reply, so that it may be forwarded to the Mines Department for copying and filing, as requested in Mr. Robertson's letter.

Yours very truly,

F. H. SHEPHERD,
Secretary to the Board.

On sending out the above letter, Mr. Shepherd acknowledged the communication of this department by saying: "I have requested the several managers and members of the above board of examiners to send in their experience, etc., with reference to carbonic oxide. I will add my own observations with the others and will forward as soon as received. I enclose copy of circular letter sent to managers and others."

Office of Chief Mine Inspector,
State of Alabama.

Birmingham, Ala., July 25th, 1906.

Dear Sir:

In response to your inquiry relative to carbonic oxide, will say that my experience and observation with this gas has been somewhat limited, as we have but very little of it in Alabama, so far as I have been able to find out.

Very truly yours,

J. M. GRAY,
Chief Mine Inspector.

Commonwealth of Pennsylvania,
Fourteenth Bituminous Inspection District.
F. W. Cunningham, Inspector.

August 3d, 1906.

Dear Sir:

I will now try to answer your letter of the 7th inst. in regard to CO, but must say that my experience with this gas has been very limited. I never encountered the gas except in the presence of a mine fire, and then it was detected by a safety lamp and by the effect on the men who were fighting the fire. There seemed to be a layer of gas along the roof, in the vicinity of the fire, and as soon as one would put his head up in it he would fall, and the effect was attributed to the gas. The lamp would burn with a very blue flame and the gas seemed to have a very peculiar effect on the nostrils. All I know about dealing with the gas and a safe means of detecting it, is given by authorities with which you are familiar. As CO has an affinity for oxygen, I do not think it would be possible for it to exist where CO is not generating for any great length of time, especially if an air current is directed to it.

Hoping that some person may have arrived at some safe method of dealing with this gas, and that you will make the same public, and wishing you success in your research, I remain.

Yours respectfully,
F. W. CUNNINGHAM.

Commonwealth of Pennsylvania,
Fourteenth Anthracite Inspection District.
James A. O'Donnell, Inspector.

Centralia, Pa., July 31st, 1906.

Dear Sir:

In answer to your communication as to a safe means of determining the presence of carbonic oxide gas in the mines, and the percentage of the mixture in the atmosphere of the mines, will say that I have only seen CO where there was a fire in the mine. I have seen men work where the gas produced an elongated flame in the lamp; I have reopened parts of a mine that was sealed for twelve and eighteen months, to put out a fire, and I have only met CO where the sealing was imperfect and the fire was still smouldering; but where the fire was quenched, in exploring the workings, I never saw or felt its effects. I had holes

bored through the sealing batteries and filled rubber bags with the gases and had the gas samples so taken analyzed by a chemist. Where the sealing was perfect the bags contained CH_4 and CO_2. In examining a mine after a fire, it would not be safe to travel except with the air current, and I would not examine any workings where there was not a good current of pure air.

Very truly yours,

JAMES O'DONNELL.

Commonwealth of Pennsylvania,
Tenth Bituminous District of Inspection.
Joseph Williams, Inspector.

Altoona, Pa., July 30th, 1906.

Dear Sir:

Your favor received and in reply will say that I have not had any experience with CO that would allow me to determine what percentage becomes dangerous. The only experience I have had with this gas has been at mine fires or after an explosion where heavy blasting has been done. In my experience with this gas in mine fires, my attention was once called to an explosive gas that was discovered by the mine foreman, where a fire had been in existence for some months, in the Robertsdale mines, Robertsdale, Pa. The foreman stated that this gas was carbonic oxide, and I failed to understand how he could discover this gas in an explosive condition, in a safety lamp, and still live. I investigated and found the location of the gas to be on a ledge which separated the top and the bottom coals, the coal having been worked over the rock a distance and the roof was at that point about twelve feet in height, and while I failed to find an explosive gas, I was satisfied that the gas was generated by the fire. The mine did not generate explosive gases. I became very sick after inspecting the top of the rock, and a couple of hours later was seized with vomiting and a terrific headache, which lasted for some hours. My opinion was that this gas was such as would be generated in a retort, the same as the illuminating gases, and that there would be some CO in the mixture. The effects were plain to be seen in the Johnstown explosion. The condition of the bodies and the amount of the after-damp, led me to form the opinion that CO played an important part in the loss of so many lives.

A case of heavy blasting came to my attention in Huntingdon county, where no explosive gas was being generated and three men were burned by a blown-out shot. The shot, which proved to be fatal to two of the men, was fired in a room on a pitch of 45 degrees, eighteen feet up off the heading, and the flame extended 200 feet along the heading. Much blasting had been done through the forenoon, and the place being in advance of the air current, the atmosphere had become very much heated, and it was the opinion of some experts that CO was being generated and conducted the flame, while my opinion was that the flame was being conducted by the coal dust. Although this coal is only 16 per cent volatile matter, I suppose there could be CO formed, but I cannot think that CO was the sole cause of the explosion.

In regard to CO getting into unventilated parts of the mine through mine fires, etc., it would depend upon the gases which were being generated. Should there be no gases generated, I believe that its condition would not change; but should there be CO_2 or CH_4 generated, then the gas would become non-explosive, as the affinity of the carbon and oxygen would dampen the explosiveness of the gas and CH_4 would require more air to make it explosive. Therefore, my opinion is that under either of the three conditions, great precautions should be used in approaching old workings, and should not be attempted without the use of safety lamps, and more than one person should be present. I have entered after explosions, five men in file, six feet apart, so that if anything should happen to the man in the lead, the other men coming up behind could rescue him. I do not know of a better way, but have read of an apparatus containing oxygen, being used in the late explosions in France.

Yours truly,

JOSEPH WILLIAMS.

Commonwealth of Pennsylvania,
Second Bituminous Inspection District.
C. B. Ross, Inspector.

Greensburg, Pa., December 1st, 1906.

Dear Sir:

On receipt of your letter I read it carefully. In the beginning I wish to say that my experience with this gas has been confined strictly to mines or parts of mines where fire existed, or in mines

after an explosion of fire damp (CH_4) had taken place. As to the percentage of this gas in the air necessary to cause death, I could not say, as I have never been present at any chemical tests, my only knowledge of this having been obtained from different writers on the subject, and the same may be said of my determining its presence in the mine, if these writers are correct, as I believe they are. I have met with this gas before quite often in such places as I have mentioned, and I find it to act on the human system and also on the flame of the lamp just as they have described it. I have noticed the creosotic odor you have mentioned as given off by mine fires and after explosions of CH_4. I have often gone into places where I suspected this gas, with an ordinary Clanney safety lamp, and by watching the flame carefully could see it inrease in both brightness and size, the change on the flame being very plain and visible. I have remained in such places for a few minutes before I could feel any bad effects. The first thing to be noticed was the odor you speak of, quickly followed by a twitching of the nostrils, accompanied by a moisture and a severe pain in the head. I would then, of course, retreat to fresh air, as it would be extremely dangerous to remain longer. I never went far from fresh air to try such an experiment, as in my opinion it would be too dangerous to venture far, and when the above symptoms are noticed it does not take long to render a person unable to travel—hence the necessity for being close to fresh air so as to take but a short time to reach it. In the first case the percentage in the air is evidently small. I have walked into the gas, not expecting it, and noticed these symptoms with the first step into it, and in this case the percentage was undoubtedly greater. On examining for this gas I proceed very slowly with a safety lamp, watching carefully for an increase in size and brightness of the flame, going for a step or two and then stopping until I am satisfied there is none present, and so on until I see the change before mentioned on the flame of the lamp, when I at once retreat, being satisfied that CO is present, and that any further attempt to penetrate it might prove dangerous. As to whether or not it would be stripped of its death-dealing qualities after it has been lodged in unventilated workings, I am unable to say positively, as I have never encountered it under such conditions; however, I am of the opinion that it would be removed by diffu-

sion; that changes in the atmospheric pressure would bring conditions about sufficient to render it harmless in a reasonable length of time. I have, however, found this gas lying near the roof in workings where the ventilating current was scarcely noticeable, it having found its way there from a fire in pillar workings, and happened to just move back as fast as it was being generated, the air current not being sufficient to dilute it and carry it off. In cases of this kind I have been able to walk under it and place a safety lamp into it, when the changes on the flame of the lamp, as previously mentioned, were plainly noticeable. Its presence can easily be detected in old workings, such as you refer to, by carefully being on the lookout for the symptoms and change on the flame of the lamp before mentioned; a numbness of the limbs or entire body is a good indication that this gas is present in the atmosphere of the mine. I have known persons not familiar with this gas to be affected in this way while making an examination of a mine in a part of which fire existed; I have also known miners to be affected in the same way while in their place of work, the gas having found its way into their place, unnoticed, from a burning section of the mine. The knowledge is only gained after a considerable experience with this gas. This gas, as you are aware, is always found where incomplete combustion is going on. I will give you one instance where this gas played havoc in an explosion here on July 10th, 1902, as it may be of interest to you.

The explosion occurred in the Rolling Mill mine of Johnstown, Pa., and caused a loss of 112 lives. Out of this number but seven bodies gave evidences of having been burned, the others having suffocated by after-damp or carbon monoxide. Physicians testified at the inquest that many of the victims showed signs of having died of carbon monoxide poisoning; every evidence of the presence of carbonic oxide after the explosion; also every evidence of incomplete combustion was present. The gas that exploded was on a fall in pillar workings where it was difficult to reach by ventilation. The concussion from the explosion was very light and the damage to the mine was small, so that repairs could be made by ten men in one day. So the explosion was not very forceful, but there was plenty of soot in that part of the mine, and this, together with the other evidences mentioned,

is proof that the combustion was incomplete and that considerable carbon monoxide was present after the explosion.

Very truly yours,

C. B. ROSS,

Mine Inspector.

Commonwealth of Pennsylvania,
Second Anthracite Inspection District.
L. M. Evans, Inspector.

Scranton, Pa., July 23d, 1906.

Dear Sir:

In reply to your letter of the 7th inst., I wish to say that I have never had any experience with CO gas, and in this respect I consider myself very fortunate to have escaped up to this time.

In France they have experimented with two dogs as nearly alike as they could secure, in two bodies of gas of the same volume. The dog placed in the CO died immediately, and the other lived for half an hour in CO2.

I believe that CO when lodged in old workings for any length of time will take up another atom of oxygen and become CO2. I believe the gas may be tested by extending a long tube into the mixture and collecting it in a bag, then having the gas analyzed.

Yours very truly,

L. M. EVANS.

Twelfth Anthracite Inspection District.

Pottsville, Pa., Aug. 16th, 1906.

Dear Sir:

In reply to yours of the 9th ult., I will state that owing to the necessary amount or volume of air that is required to dilute the large quantities of gas, CH_4, which is given off in our country here, we rarely have any experience with CO. We have found where fires have occurred in some of our collieries, from which the gas was escaping through crevices and breaks to the surface, numerous birds and other small animals, lying dead. As you are aware, CO is developed in mines (1) by mine fires, (2) by use of steam locomotives, (3) by heavy blasting of powder caused by incomplete combustion and not sufficient air to dilute it. One per cent of CO is dangerous to life. We have used naked lights where a great deal of powder was consumed and CO distin-

guished itself by causing the flame of the lamp to increase in length to twice its natural size. The safety lamp being used in its presence will show the flame in the same manner as the naked or open light. The color of the flame in the safety lamp is dark red, mingled with light blue. Before either of the above causes or conditions may arise, you or any person who may be working near it will suffer in the following manner: Very sick headache, palpitation of the heart, and weakness of the limbs. This is from actual experience.

Should this gas be carried to an abandoned part of the mine where there is not sufficient air to dilute it, it will become explosive, but not as violent as CH_4, and will so remain until removed.

Should it become necessary for you at any time to make an investigation of this gas, where it is produced by mine fire, we would advise that you do at all times carry your air by brattice or other means with you. On any other occasion except fires, the human system will detect its presence as described before. As we find CO in the mines, we must say there is an odor attached to it that we are unable to describe.

We remain, very truly yours,

M. J. BRENNAN,
JOHN CURRAN,
Mine Inspectors.

Commonwealth of Pennsylvania,
Fifth Bituminous Inspection District.
Isaac G. Roby Inspector.

Uniontown Pa., July 25th, 1906.

Dear Sir:

Your favor of recent date at hand and contents duly noted, and beg to say in reply that my experience has been little in the handling of CO. I at one time, while removing stumps in a mine that a fire had worked up to, ignited some CO that had been generated by the fire. However, there was a very small volume ignited and no damage resulted. The flame from the explosion was blue. Six or eight men were engaged in removing the stumps and all of them became very sick. I note in an institute lecture that it is claimed that 2 per cent of CO, if breathed any length of time, will produce 50 per cent saturation

of the blood, and that 3 per cent will produce 65 per cent saturation of the blood, which is likely to set up paralysis in any part of the body. This lecturer claimed that the affinity between the haemoglobin of the blood and CO is 250 times greater than oxygen, so that when there is even a trace of CO in the atmosphere, the blood absorbs it to the exclusion of oxygen, and as the percentage increased, the victim soon becomes paralyzed and passes into a comatose state, finally resulting in death. An American by the name of Wilson, experimented by placing rabbits and mice in different percentages of CO. In ten minutes after a rabbit was placed in a mixture containing 2 per cent, the fore parts became paralyzed, and in 18 minutes the hind parts were similarly affected; at the end of 20 minutes the rabbit became in a semi-comatose condition, and at the end of 45 minutes the conditions did not appear to be changed and the rabbit was revived in fresh air. In a mixture of 2½ per cent, the rabbit became semi-comatose in five minutes, and revived immediately in fresh air; with 4 per cent death resulted in 4½ minutes. A mouse died in 2 per cent in ten minutes. I do not know of any practical test having been made of this gas in a mine, and would consider any such experiment very dangerous. I have assisted in re-establishing ventilation in mines, on three or four occasions, where there was a greater or lesser percentage of CO, and found it to be exceedingly dangerous.

Very truly yours,

I. G. ROBY.

Department of the Interior,
United States Geological Survey.

Washington, D. C., July 26th, 1906.

Dear Sir:

I regret to say that no satisfactory answer can be given to your letter, received here the 24th inst. The subject of carbonic oxide in coal mines has not as yet received any satisfactory attention in this office. Whether the subject will be taken up later in connection with the coal testing plant, is as yet undetermined. The detection of carbonic oxide in mine gases, is not easy. The test which is commonly adopted is that known as the blood test. The flame tests are not sensitive or certain enough to be of much value. It is very doubtful whether carbonic oxide in any danger-

ous quantities is likely to occur in coal mines, except as a result of after-damp. When explosions have occurred with imperfect combustion, then carbonic oxide may be present in dangerous quantities. Small traces of it are undoubtedly unwholesome, but the danger from them is probably exaggerated. Large quantities are undoubtedly deadly. The subject is one which needs much more thorough investigation than it has yet received. I am informed that the subject has been recently studied with more care in Germany, but the final report of the investigations made there have probably not been published as yet.

I regret that I can not give you more explicit information on this theme.

Very truly yours,

H. C. RIZER.

Floyd Davis, E. M., Ph. D.
Analytical and Consulting Chemist.
Des Moines, Iowa.

July 20th, 1906.

Dear Sir:

Your letter of the 7th inst., addressed to our State Mining Board, has been handed to me for reply, as it comes under my line of work as a chemist to look into matters pertaining to poisoning.

The common method of detecting carbonic oxide in a mine, by its effect on a flame, is known to all engineers as not being sufficiently delicate for practical purposes. Hence in an investigation for this gas in old workings, mice are frequently used on account of the rapid and prominent symptoms of poisoning which carbonic oxide develops in them. Mice are more susceptible to the action of this gas than is the human system; hence, when a mouse is conveyed into the workings of a mine and manifests symptoms of dizziness, increased rapidity of breathing, shortness of breath, staggering, or is entirely overcome and dies, it is quite evident that there is present too large an amount of this poisonous gas for men to work in.

But more delicate and exact is the chemical method of testing for its presence by means of a dilute solution of blood. If water containing but one per cent of blood, which of itself has a pale, yellow color, be shaken up with air containing even a trace of carbonic oxide, the solution changes to a pink color, and this is a reliable test when properly performed. It will readily

show with air containing less than 1-10 of one per cent ,and as air containing 5-10 of one per cent, has to be breathed for a long time before it causes death, you will easily see that this blood test is an excellent one for delicate investigations.

Carbonic oxide is not absorbed to any extent by moisture and does not form combinations with the constituents of rocks. So that when it is once generated from the burning of gobs, mine fires or explosions, it is likely to remain where the conditions are favorable for storing it up, as in old workings or in parts of a mine which are not ventilated. I believe you will find this chemical method of detecting the gas very satisfactory, and in performing it you should notice that the symptoms are singularly persistent, while with carbonic acid they are only transitory.

Very truly yours,

FLOYD DAVIS.

Washoe Copper Company,
Coke Department,
Storrs, Montana.

Dear Sir: July 16th, 1906.

In regard to the best method for detecting CO in mines, will say that the ordinary safety lamp is as good as anything that I know of and yet it is very unsatisfactory. My experience has been that the very best way to detect it is by its effect on the respiratory organs, coupled with the effect the gas has on the lamp. Several times in my experience I have detected gas in this way, but only with the exercise of the greatest care. During mine fires, or under any conditions that make the generation of this gas possible, the greatest possible care should be used in approaching that part of the mine, and only experienced workmen should be allowed to act as explorers and even then there is an element of risk, which in my opinion can not very well be wholly eliminated. It is, of course, quite possible for white-damp to accumulate in a mine without any previous known cause, but in the ordinary occurrence there are conditions existing, such as gob fires or fires caused by ignition, or the residue of gas left after a mine explosion, that we may expect to give off CO. Under such conditions the exercise of the care mentioned ought to safeguard the men in the mine.

There are many things about mining that we are not acquaint-

ed with and among these is a lamp that will detect, or indicate the presence of CO, as well as we now detect fire damp.

Yours truly,
GEO. N. GRIFFIN.

Mr. J. B. McDermott,
State Coal Mine Inspector.

Red Lodge, Montana, Dec. 1, 1906.

Dear Sir:

I received your communication of Nov. 2nd and regret that I could not get around to make an earlier answer, but trust this will reach you in time for the report.

I will give you as full an account of the accident as my memory will permit, together with my movements on the 7th of June, until I became unconscious.

I left home at about 7:30 a. m. June 7th, going directly to the office where the company issues checks to the company men for the purpose of keeping a correct account of the time they work. There I met Mr. Pettigrew the general superintendent of the company. He told me about the condition of the water level as far as he knew at the time; also where we were to work and how to go; he also informed me who was to have charge of the shift. From there I went to the mouth of what is called the water level, there to wait until all the men were ready to enter the mine together. At about ten minutes to eight we started in the water level, there being 13 men. We proceeded in single file, Mr. Thos. Skelly taking the lead and I next. We went in the mine about 1,000 feet. There the air was mixed somewhat with blackdamp, which we noticed was coming through a wall that was built across one of the old entries. At this point I asked if we were getting the full current of air and was told by Mr. Sam Newman that we were getting only about one-third of the air that was going down the incline, the rest of it coming from an air shaft. We continued on into where the fan is located; there we waited until all the men had come up to us. Mr. James Fleming then took the lead through the fan house to the top of the incline. In passing the fan we all got in the dark. After getting a light we all continued down the incline, Mr. Skelly again taking the lead and I next. On reaching a point on the incline where the air turned to go into the third west entry,

vein No. 5, we again waited until the men had all got up to us. At this point we noticed the air was not travelling the way it should do. Also that some of the men had stopped between the fan and the place we then were. Mr. Skelly and I then went to the bottom of the incline, to where there was a door, to see if we could get through that way. Upon reaching the door we considered the advisability of opening it, thinking that the night shift were still working on the fire, and using the No. 2 fan air. We then went back to where the other men were waiting for us and we then tried to go through No. 12 room to the 3d west entry, but could not do so on account of damp. We returned to the incline and upon noticing the fresher air, we noticed we were somewhat overcome. The other men noticed it also and some of them started up the incline. Those who were left sat down and tried to think of some way of getting out without going back up the incline, but could not do so. We then started up the incline. In a stooped position, I was somewhat dizzy and had a buzzing sensation in my ears; also my breathing was heavy. The further up the incline I went, the harder became my breathing; also my legs were weak, until at last I tried to crawl, then to lay down and draw myself along by getting hold of the rails. At last, seeing my progress was so slow, I made a hole with my hands and put my mouth and nose in the dirt, and became unconscious almost at that instant. That was the last thing I remember until I returned to consciousness at about 7 o'clock that evening.

Replying to the questions: Before becoming unconscious I had a dizzy sensation; there was a buzzing in my ears; my chest seemed to tighten and would not allow my lungs to expand; my legs weakened to such an extent that they became useless; my brain was clear and my eyes were not effected at all. I noticed no other effects. Fraternally yours,

WM. TARLING.

(Mr. Tarling was one of the day shift of 13 and was rescued in an unconscious condition.)

Red Lodge, Montana, Nov. 7, 1906.

Dear Sir:

As nearly as I can recollect, my experiences in the white-damp were as follows: Before I became unconscious there was a distinct buzzing in my ears; my eyes watered, but I do not recol-

lect any peculiar effect on the brain; my legs became so weak that I could not stand on them, but while I remained conscious my arms seemed to retain their muscular power. On recovery I was grinning and shaking like a leaf, and my stomach was sore for some days and I did not have any appetite

Yours truly,

JOE. WOOD.

Mr. Wood was one of the original day shift of 13 men who, with Mr. Matt Kintalla, made their escape unaided and bringing the first intelligence to the surface of the location of the others of the day shift, six of whom were later brought out dead and two unconscious, who were resuscitated and eventually recovered—Mr. William Tarling and Mr. H. L. Bolyard.

Red Lodge, Montana, Nov. 8, 1906.

Dear Sir:

Yours of the 17th received and will say in reply * * * my first sensation was dizziness or swimming of the head, but this effect soon passed away. I then experienced a period of excitement, and this did not last long. My thinking faculties seemed to remain active and normal. I did not notice any effect on the eyes, nose or ears. My lungs felt as though they could not get a sufficient supply of air and it seemed as though the harder I breathed the less air was conveyed to my lungs. I did not experience any pain. My legs became useless, seeming to be paralyzed, so that I had to pull them along in dragging fashion in an effort to walk. This paralysis came on by degrees, but was not long in becoming total, perhaps five minutes. My arms were not similarly effected, but I noticed, before I was completely prostrated, that they were also becoming weak. There was no effect on the stomach. I do not think I was in the gaseous atmosphere more than 25 minutes before I was in a completely collapsed condition.

Very truly yours,

H. L. BOLYARD.

Stockett, Montana, Nov. 5, 1906.

Dear Sir:

I have read your communication carefully, and in answer must say that I have never had any experience with carbon monoxide,

never having worked where it was known to exist, to my knowledge. Very truly yours,

M. F. PURCELL.

Minister of Public Works of France.

Dear Sir:

I have received your letter of the 3d of August, 1906, in which you ask me certain information about the means that have been employed in the French mines to ascertain the presence of oxide of carbon.

Just at present no particular means are prescribed in this matter, but following certain facts which will be presented in the event of works of salvage undertaken in the mines of Courrieres, the Commission of the Grison, instituted near my department, has been invited to study the question and to seek the surest and most practical way to reveal in the atmosphere of mines the quantities of oxide of carbon which may be dangerous. If these studies give satisfactory results, the measures which shall be ordered will be the subject of a publication, and it will then be possible to reply to your request.

Receive, sir, the assurance of my most distinguished consideration.

A. CHARGUEIAN,
Minister of Public Works.

Berlin W. 66, August 29, 1906.

Dear Sir:

Replying to yours of August 6th, inst., regarding our experience in Prussia with carbon monoxide gas in coal mines, I beg to say the following:

According to Jicinsky's treatise on coal mine explosions, and also according to Dr. Brockmann, carbon monoxide (CO) is a very poisonous, colorless and odorless gas of the specific gravity of 0.97. It originates through the incomplete combustion of carbon and also when carbon dioxide (CO-2) is brought in contact with reducing bodies such as iron, copper or carbon at a high temperature.

It is claimed that when there is but 0.05 per cent of carbon monoxide in the air, that it is not dangerous to human life, but that 0.1 per cent produces headache, and 0.2 per cent produces unconsciousness and death.

The presence of carbon monoxide in the Prussian coal mines was particularly observed in the so-called "Nachschwaden," resulting from a "Schlagwetter" explosion particularly in the presence of coal dust or as a consequence of a pure coal dust explosion; in the gas originating from fires in coal mines; in gases arising from defective and badly mixed explosives or incomplete explosion, caused by a too weak igniting cap. This can happen especially when dynamite is used in blasting coal mixed with coal dust.

Special methods for the discovery of carbon monoxide present in coal mines, have not yet, so far as we know, been put to the test in our coal mines. The Davy lamp is considered of little value, as the flame does not indicate as small a percentage of carbon monoxide as 0.2, which, as above stated, acts fatally, and because the flame of carbon monoxide can not be distinguished from that of methane (CH-4), making it out of the question to rely on the lamp as a means of detecting small amounts of CO. With small animals such as rats and mice, which are much more sensitive to carbon monoxides than men, good results have been obtained in detecting the presence of the poisonous gas in coal mines. As an instance we may refer to the experience in the Snaefell disaster.

In Prussian coal mine districts in which fires and explosions have occurred, frequently samples were taken of the gas at the spot, transferred to chemical laboratories and subjected to analysis. In the laboratory of the West phalen Mine Owners' association at Bochum, the gas to be analyzed for carbon monoxide is introduced into copper chloride or palladium chloride and then the amount of carbon monoxide is determined after Dr. Brockmann's method in the journal previously cited.

In the Prussian coal mines, the men employed in the life saving service, after explosions and coal mine fires, are requested not to enter the mines unless well equipped with respirators and oxygen supplying apparatus and no one else is admitted until all the poisonous gases are removed by the introduction of large amounts of fresh air with the aid of ventilators and pumps.

Regarding the question as to whether the carbon monoxide accumulating in old coal mine tunnels will become neutralized or dissipate, it was satisfactorily demonstrated that after some time it loses its deadly properties by mixing with other gases and effecting its disassociation. It was also demonstrated in the

Silisian coal mines, that it is possible to so close up a burning coal mine that no more new carbon monoxide can gain access to surrounding places. The carbon monoxide contained in the gases of the burning district evidently combines with a part of the remaining available oxygen, and the hydro carbon present is also decomposed, taking up oxygen under formation of carbon dioxide and water. The closing up of the places where explosions or fires are existent with the aid of impervious dams. has been so successful that it was found upon making test opening and analysing the gases escaping therefrom, that explosive or fire gases were no longer present, but only strong carbon dioxide. (Beyling Journal for Berg-Hutten and Salinenwesen in Preussischen Staat, 1902, page 128.) The examination of carbon dioxide from the dammed up explosion district, is proof that the danger has passed, and after the removal of the carbon dioxide by forcing plenty of fresh air into the mine, it can be entered safely.

Very truly,

The Prussian Minister for Commerce and Industry.

By Von Vardn.

PRECAUTIONS AND TREATMENT.

The following are excerpts from an address delivered before a session of the International Mining Congress, by Dr. George W. King, of Helena:

"Accidents from the inhalation of poisonous gases is a subject of special interest to miners, on account of their frequent exposure while working underground. The best ventilated mines are not entirely free from this danger, and as a consequence miners are sometimes overcome by breathing gases collected or generated in stopes or recesses that cannot be wholly purified. Where good ventilation has not been provided, as in shafts and tunnels projected by prospectors, the danger is proportionately increased. The attempt to return too soon after blasting has occasioned loss of life. The introduction of compressed air as a motive power in the larger mines is of signal service in this particular. After blasting, the air is turned on and the noxious gases driven out before the men resume their labors. The candle test for unsafe air is observed by miners generally. They know that an atmosphere too poor in oxygen to support the flame of a

candle is unfit to breathe, and precaution must be taken to avoid such localities when it is possible to do so. They should also understand that this test is not infallible. There may be, and often is, an admixture of gases capable of supporting the flame from a candle and yet deadly when inhaled. Experienced miners can not have failed to note the behavior of the candle flame under these conditions. It flares up with a pale bluish light, due to the presence of a gas known as carbon monoxide. It is one of the most poisonous gases with which miners come in contact. A product of imperfect combustion, it is generated by the detonation of explosive compounds, and being colorless, odorless and tasteless, its presence is only made apparent by certain symptoms produced by its poisonous action when introduced into the blood by continuous inhalation. Associated with the ordinary carbon dioxide which infests the mines, in as small a proportion as 1 per cent it may prove injurious. A combination of the two gases seems to increase the toxicity of each other. Carbon dioxide is fortunately less active than the monoxide; moreover, it has a slight taste and odor and can therefore be more readily detected. The two gases are generally associated together and the chief concern is to be able to determine when their percentages in the atmosphere have passed beyond the limit of safety.

It is true that a difference of opinion exists among individuals in regard to their susceptibility to the acton of these gases. One may be overcome in a place where another suffers but slight inconvenience. This fact often encourages the latter to take unnecessary chances. Men of experience and judgment, however, rarely go into a place where the air is known to be bad without being prepared to retreat promptly upon the first indication of danger. What these indications are should be as familiar to the trammer as to the miner himself, for it is among the former class that accidents from the inhalation of foul air is most liable to occur. Their work necessitates the handling of loose earth, which is more or less impregnated by the gas, which is easily freed by the disturbance and becomes mixed with the air to be breathed. Poisoning by carbon dioxide is at times so insidious that the warning symptoms are unnoticed until too late to escape.

Symptoms of poisoning by carbon dioxide: The smell and taste of the gas is usually quite perceptible and this indicates its presence when the percentage is small; nothing more than a

slight dryness of the throat and a headache may be experienced. In large amounts the headache becomes more intense, a peculiar throbbing pain is felt over the brow and back of the head. Vertigo supervenes and the sight becomes dim and the limbs weak. There is nausea and vomiting. An uncontrollable desire to sleep comes on, and the person falls, never to rise, unless carried out immediately. In an atmosphere completely saturated with carbon dioxide, these progressive symptoms are not noted for the reason that all is over in a very few moments.

The result is practically the same as being submerged in water.

To rescue those who are insensible, a systematic plan of relief should be adopted. To rush in excitedly but complicates the work, very likely adding to the number already disabled. It is suicidal for any one to attempt a forced entrance into an atmosphere unfit for respiration. As the diver before descending into the depths is careful to have himself protected from all possible accidents, so should the miner with like care equip himself for the hazardous journey he is about to undertake in his efforts to save the lives of his fellow workmen. A helmet with a reservoir of oxygen or gas or compressed air and a portable electric light, will enable him to go directly to the spot indicated, while still retaining his strength and faculties, so needful for the arduous work before him. Two men thus equipped, should work together as a matter of precaution. When not so equipped, by forming a relay of men and instructing the one who is to enter to apply a sponge or handkerchief saturated with water, or preferably, vinegar, over the mouth and nostrils, then to go quickly forward, take hold of the one insensible, and drag him toward the entrance as far as he can with safety to himself, then retire to give place to one who stands ready to succeed him, will render the rescue work less hazardous to all concerned. Operating in a shaft is more difficult and dangerous. When the descent is made by a bucket for any considerable distance through a poisoned atmosphere, it is impossible to stand erect within it and maintain an equilibrium after the paralyzing effects of the gas is experienced. A sitting or kneeling posture should therefore be assumed to avoid the possibility of being precipitated from the bucket. Should descent by ladder-way be undertaken a rope fastened about the waist and manned from above is recommended as a wise precaution. A second rope may be lowered

if necessary, and made fast to the person to be brought up by means of a loop drawn snugly around the body close under the arms. The act of hoisting an unconscious person by the aid of a rope must be conducted with considerable care; the tension ought to be steady lest too forcible contact with jutting timbers or rocks result in serious injury.

The resuscitation of those who have been overcome and rendered unconscious by the inhalation of poisonous gases is necessarily first aid work. The question of how best to accomplish this object, is worthy of consideration. Little can be done before the removal to a location where the air is comparatively fresh. In cases of profound collapse, with pulse absent at the wrist, a hypodermic injection of ether may temporarily stimulate the flagging heart and thus serve to keep life in the body during transportation. Some member, or all of the regular rescue force, should be taught the use of the hypodermic syringe for this purpose. The instrument, charged and protected in an asceptic package with the point of the needle imbedded in a small rubber cork to prevent evaporation of the ether; it is quickly available and can be used without delaying the work for an instant. The injection is easily made while the patient is being carried along upon the litter. The method is simple; the needle is inserted into the upper and posterior part of the thigh or buttox and the piston pushed down. It must not be forgotten that there is considerable additional shock to the patient upon sudden emergence into a pure atmosphere. This is in a measure guarded against by the previous administration of the ether as above noted. When arriving at the surface, if the breathing is suspended or but faintly perceptible, artificial respiration must be resorted to promptly. The inhalation of oxygen is of the greatest service at this time. It is the most direct stimulant to the respitory center and enters the blood by the way of the lungs, displacing the carbon monoxide from the oxygen carriers, the red corpuscles, and at the same time the poisonous gas is eliminated by the act of respiration. The oxygen is administered by the use of a suitable inhaler attached to the cylinder in which the compressed gas is stored. These cylinders are returned to the factory and refilled at a nominal cost when exhausted. An extra supply ought at all times to be kept on hand. After the breathing becomes regular and the patient is able to swallow, stimulants are chosen on account of their quick action. The aro-

matic spirits of ammonia in half to one teaspoonful doses, diluted in a wine glass full of water, or a mixture of the above with equal parts of the compound spirits of ether, is in some instance to be preferred. Warmth to the body is an essential part of the treatment; this applied by wrapping the patient snugly in a blanket and placing bottles of hot water underneath. First aid ends here and the subsequent treatment is left to the medical officer.

Inspector of Mines,
Manchester, England.

Worsley, Manchester, Dec. 18, 1906.

Dear Sir:

I have been endeavoring for some time to get you information regarding the poisonous gases in mines * * * and at last have got some information that is given very clearly.

Yours truly,
JOHN GIRRARD.

The information provided is the following paper of Frank E. Thompson, A. R. C. S., Lond., A. I. C., F. C. S., etc., Analytical and Consulting Chemist, read before the South Staffordshire Mining Schools' Old Boys' Society, October 27th, 1906:

Carbon when burnt is capable of forming two different oxides, carbon dioxide (carbonic acid gas) CO_2, and carbon monoxide (carbonic oxide) CO. With an abundant supply of oxygen the carbon is fully burnt to carbon dioxide, but when the supply of oxygen is limited, then a more or less amount of carbonic oxide is formed, as shown by the following equations:—

(Excess of oxygen) $= C + O_2 = CO_2$.

(Oxygen limited) $= C + O = CO$.

Although carbon dioxide is a poisonous and suffocating gas, carbonic oxide is a much more poisonous and disastrous gas, and very quickly kills when inhaled. Carbon monoxide was first discovered by Lassone in 1776. He obtained it by reducing zinc oxide with carbon.

$ZnO + C = CO + Zn$.

Cruckshank proved this compound to be an oxide of carbon in 1880.

There are many ways by which it can be obtained, but I shall only refer to those which are of importance to the miner.

(1) When carbon is burnt in a limited supply of oxygen.

$C+O=CO$.

(2) Carbon dioxide passed over red hot charcoal is reduced to carbonic oxide.

$Co2+C=2CO$.

The blue flame often seen on the top of a well burnt fire is generally produced by carbon monoxide burning to carbon dioxide.

$CO+O=CO2$.

The carbon monoxide having been formed by carbon dioxide passing over the red hot coal in the fire. (No. 2 method).

Carbon monoxide is a compound containing one atom of carbon united with one atom of oxygen. It is a colorless, tasteless gas, with a very faint smell.

At a temperature below — 193 degrees C., it becomes a liquid, and at — 211 degrees C, it becomes solid. It is a shade lighter than air, its specific gravity being 0.967 (air=1.) The gas dissolves in water to a very slight extent. Carbon monoxide is a combustible gas, burning with a blue flame to form carbon dioxide.

$CO+O=CO2$.

When mixed with half its volume of oxygen, or two and a half volumes of air, an explosive mixture is obtained. Such a mixture readily explodes on the application of a light, or on coming in contact with anything red hot.

Carbon monoxide is a very strong poison, and when inhaled acts on the blood in the following way: Blood contains a compound called haemoglobin, which is the coloring matter of the red blood corpuscles. In the ordinary process of respiration, the haemoglobin combines with the oxygen in the lungs and carries it to the various tissues of the body, and so life is sustained. When carbonic oxide is present, the haemoglobin in the blood combines with it, forming a fixed compound, carbonic oxide haemoglobin, which gives to the blood an extremely bright-red color, and makes it incapable of absorbing oxygen from the air. The tissues are then no longer fed with the oxygen necessary to support life, and consequently death follows. Haemoglobin has 250 times more affinity for carbonic oxide than oxygen has. Therefore in inhaling air containing carbonic oxide, the blood quickly absorbs this gas in preference to oxygen. In breathing

an atmosphere containing only a little carbonic oxide the blood continues to absorb the carbonic oxide until it is saturated, and fully charged with carbonic oxide haemoglobin. Stevenson states that 0.1 per cent of carbonic oxide in air is capable of destroying life. French people frequently commit suicide by poisoning themselves with this gas. They burn charcoal in a closed room and then inhale the fumes which are given off. An atmosphere so produced gave on analysis:

Carbon dioxide=4.6 per cent.

Carbonic oxide=0.5 per cent.

A large number of manufacturing processes produce mixed gases which contain some carbonic oxide,

During the combustion of charcoal and coke a mixture of carbon dioxide and carbonic oxide is produced because there is not sufficient oxygen present for the complete oxidation of the carbon to carbon dioxide. More or less carbonic oxide is always contained in the gases given off from slow combustion stoves, gasoline stoves, blast furnaces, and regenerative furnaces. It is produced in lime burning. Tramps sleeping by a lime kiln have been poisoned with the fumes given off which contain both oxides of carbon.

Water-gas, which is manufactured by sending steam over red hot coke, is chiefly a mixture of carbonic oxide and hydrogen. Usually about 40 per cent of carbonic oxide is present. Coal gas chiefly owes its poisonous properties to the small percentage of carbonic oxide which it invariably contains. Carbon monoxde is often formed in mines from heated coal, owing to its incomplete combustion. Fires in mines generally produce appreciable quantities of carbonic oxide. When blasting powder is used the gases formed contain carbonic oxide.

As previously stated, carbonic oxide mixed with air forms an explosive mixture. In a mine where coal dust is present, a mixture of air and coal dust with only a little carbonic oxide forms a highly explosive mixture.

Explosives should not be used in a mine which by their combustion yield inflammable gases which are only partly burnt. Miners should exercise great care in using suitable explosives, as corbonic oxide may easily be formed when explosives are not properly used, particularly in parts of a mine which are not well ventilated. In Dr. J. S. Haldane's report to the Home Office on the cause of death in colliery explosions and underground

fires, he proved that the majority of the fatal cases are really caused by poisoning with carbonic oxide, which is contained in the after-damp. His statistics show that 77 per cent of the deaths are due to this cause. It is generally supposed that the miners are not overtaken by the after-damp until one or two prove fatal owing to the presence of carbon monoxide, or death

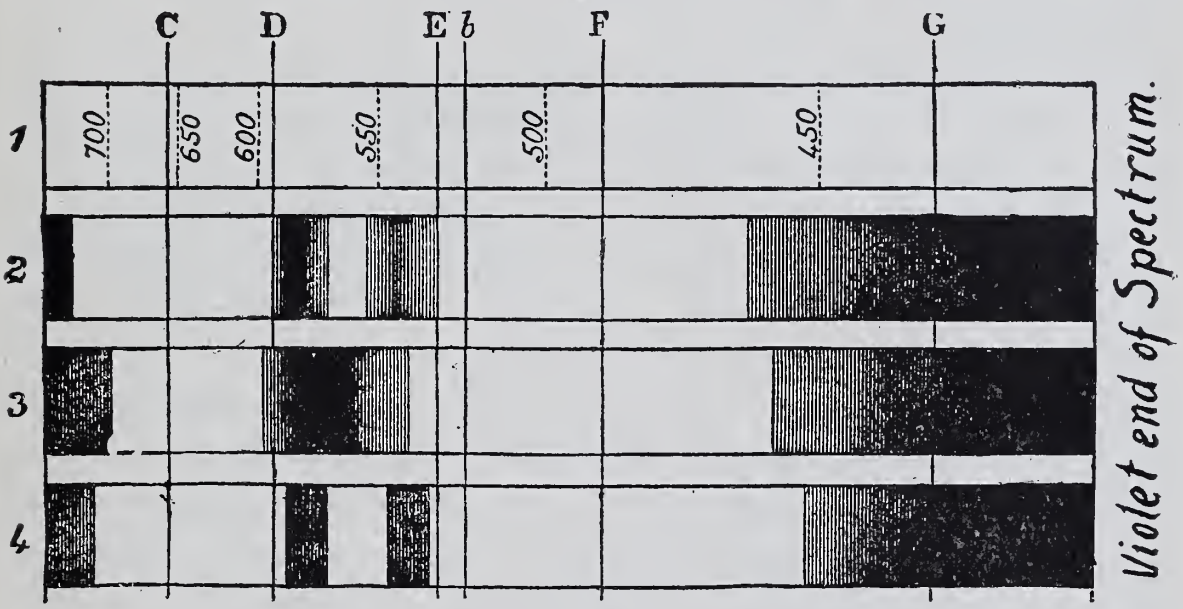


FIGURE 1.

1. Solar Spectrum.
2. Spectrum of Oxy-Haemoglobin; Normal Blood (Dilute Solution).
3. Spectrum of Haemoglobin.
4. Spectrum of Carbonic Oxide Haemoglobin.

may be due to the absence of air or oxygen. When carbonic oxide is present, the blood is rendered incapable of absorbing oxygen by the reasons previously stated. In the absence of air or oxygen, the after-damp would prove fatal when breathed, as death would be caused by suffocation. The presence of carbon monoxide therefore produces the same effect as the deficiency or absence of air or oxygen.

A person may inhale carbonic oxide without knowing it, for it is colorless, does not irritate the air passages, and tends to act as a narcotic, consequently a victim would perceive no sign of danger until the gas produced its own physiological effect. Alcohol, in many ways, produces similar symptoms. The physiological effect of any poison may vary according to the idiosyncrasy of the person, but in the case of poisoning by carbonic oxide the following effects are usually observed: A loss of power and movement and desire to make any exertion. On trying to walk

the legs give way, which renders a person inhaling the gas incapable of escaping from it. Headache, giddiness, noises in the ears, nausea, and sometimes vomiting occur; also great prostration, insensibility, and coma.

When a case is fatal convulsions generally precede death. The following is an interesting account of the effects of carbonic oxide:

On June 15 last a fire occurred in the main head of the shallow seam of a certain colliery. The fire was caused by the ignition of the coal in the back of the heading by the firing of a shot of saxonite, to which had been added one cartridge of compressed powder. On Sunday, the 17th, an inspection of the place was made. The smell of the smoke resembled coal gas and produced both in the inspector and his assistant a feeling as if the head were too heavy; this was accompanied by a slight nausea, at first followed by singing in the ears, burning of the face, and headache. The inspection lasted about an hour, and on returning to the bank a crude method of revivification was adopted, viz., inhaling oxygen generated in an open pan.

A safety lamp showed a large cap, freqnently tinged brown. On the following Tuesday it was noticed that the smoke had a very pungent acrid smell, due no doubt to burning timber; this got worse, and on Wednesday a visit was paid to a return airway 500 yards from the fire. No smoke was observed, but the stink was strong and produced nausea. On returning to the fresh air, sore throat, pain in the neck and shoulders, aching of the arms, and severe panting were noticeable symptoms. One man was keenly affected, suffering violent headache. On his arrival at the bank he sat down in the rain, and it was with difficulty that he was persuaded to inhale the oxygen.

Dr. Haldane states that the first symptoms of poisoning by carbonic oxide appear when the blood contains 30 per cent of carbonic oxide. When 50 per cent is present, paralysis sets in and death occurs with 80 per cent.

The blood would become charged with 30 per cent of carbonic oxide by inhaling an atmosphere containing only 0.06 per cent of carbon monoxide for an hour and a half; 0.1 per cent of carbonic oxide present would cause headache and paralysis, but would not cause complete unconsciousness. A victim who had been in such an atmosphere for a long time could be restored by

breathing fresh air or oxygen; 0.2 per cent would cause death even before the blood had had time to become saturated with carbonic oxide. An atmosphere containing more than 0.15 per cent of carbonic oxide is exceedingly dangerous. The smallest amount of carbonic oxide which, on continued breathing, would create a visible effect on any exertion being made, may be regarded as about 0.03 per cent. The blood of an average man measures about five and a quarter pints, and is capable of combining with about one pint of carbonic oxide.

Dr. Haldane states that when inhaling carbonic oxide gas unconsciousness rapidly takes place, but death does not follow for a period of one and a half hours, hence the necessity of bringing the victims quickly into the fresh air, and adopting the proper remedies as rapidly as possible. The victim should be quickly moved from the poisonous gas and well wrapped in warm clothing, for on reaching a colder and fresher atmosphere the patient usually becomes worse owing to the sudden change. In alcoholic poisoning a similar effect is often produced. At once give inhalations of oxygen; use artificial respiration if the breathing ceases or is very shallow, and administer stimulants when the pulse is weak.

According to Dr. Haldane, the removal of carbonic oxide from the blood proceeds five times as rapidly with pure oxygen as with fresh air. Blood quickly absorbs carbonic oxide on account of its great affinity for the blood, therefore its removal by proper oxygen treatment is much slower than its absorption. The amount of oxygen to be inhaled by a person necessarily depends upon the quantity of carbonic oxide absorbed. Dr. Haldane recommends an average of ten minutes breathing of oxygen, which would take about two cubic feet. A few breaths may restore consciousness, but much more would be needed to clear the blood sufficiently to enable the man to walk. Cylinders of oxygen should be kept in readiness at every mine. The most convenient size would be bottles holding about four cubic feet, which can be conveniently carried on a man's back. The oxygen in each bottle would restore two men. Rescue parties should be fitted with pneumatophors and rubber balloons. The balloons can be filled with oxygen from the cylinders, as required. Each balloon is fitted with india-rubber tube, to which is attached a small hard vulcanite tube, made so that it can be pushed into

the nostrils of the victim. Gentle pressure is then applied to the balloon and a current of oxygen is forced into the nostrils. Each man in the rescue party should be fitted with an electric lamp fastened round his body so as to leave the hands free.

Post-mortem appearances—Stains have a bright pink color, the skin is pale, the eyes are bright and staring, the pupils dilated, and the jaws are fixed. The blood has a bright-red cherry color, which is due to the compound formed of carbonic oxide with haemoglobin. The spectrum of blood fully saturated with carbonic oxide contains two bands of carbonic oxide haemoglobin (see diagram No. 4, Fig. 1). They resemble the bands of oxy-haemoglobin (diagram 2), but are a little nearer the violet end of the spectrum, and are more refrangible than the latter. When making a spectroscope examination of blood for carbonic oxide, the spectrum obtained should always be compared with the spectrum of normal blood (diagram 2); the difference is then clearly seen.

Confirmatory Test—Add to the blood a reducing agent—Stoke's solution or yellow ammonium sulphide, and then examine its spectrum.

Blood fully saturated with carbonic oxide will not have its spectrum affected by the reducing agent, as the carbonic oxide is firmly combined with the haemoglobin. The spectrum will still show the two bands of carbonic oxide haemoglobin.

(Diagram 4.)

Blood containing no carbonic oxide will have its oxy-haemoglobin spectrum (diagram 2) changed to a one banded spectrum, owing to the oxy-haemoglobin (haemoglobin in union with oxygen) being reduced to haemoglobin.

(Diagram 3.)

Blood partly saturated with carbonic oxide will have its spectrum partly changed owing to the presence of a mixture of carbonic oxide haemoglobin and oxy-haemoglobin. The oxy-haemoglobin is reduced while the carbonic oxide haemoglobin remains unaffected, therefore the spectrum will show a broad band for haemoglobin on which are superimposed the two bands of carbonic oxide haemoglobin.

NOTE—Stoke's Reagent—To a solution of ferrous-sulphate add a little tartaric acid, and then ammonium-hydrate until the mixture is alkaline. This solution must always be freshly made.

Second Test—To one part of blood add nineteen parts of distilled water, and an equal volume of sodium hydrate solution (S. G. 134).

Blood containing carbonic oxide—Becomes momentarily turbid, then clear and of a light red color.

Normal blood—Changes to dirty green.

Third Test—Dilute the blood with water.

Blood containing carbonic oxide—Will then have a pink color.

Normal blood—Will then have a yellow color.

NOTE—This test is very delicate and should not be performed in broad daylight, which would affect the test.

DETECTION OF CARBONIC OXIDE.

1. Mouse Test—The symptoms of carbonic oxide poisoning show twenty times more quickly in a mouse than in a man; therefore, when entering a suspected atmosphere it is advisable to take in a live mouse, which will quickly indicate the presence of a poisonous proportion of gas. In an atmosphere which would be dangerous to a man in about twenty minutes to half an hour, the mouse would show signs of weakness in the legs. In an atmosphere which would become dangerous to a man in a few minutes, the mouse would at once collapse, and be unable to stand. In a very bad atmosphere where there is great danger the mouse would become unconscious and go into convulsions.

2. Thorpe's method will detect three parts of carbonic oxide in ten thousand parts of air. Aspirate gas over powdered glass moistened with dilute blood. Well wash the blood off the glass into a suitable vessel, and shake with a few drops of ammonium-sulphide, and examine by the spectroscope for the absorption bands of carbonic oxide haemoglobin.

3. Palladium chloride will detect one part of carbonic oxide in ten thousand parts of gas. Bubble the gas in a very thin stream through 100 c. c. of a solution consisting of one part of palladium-chloride in ten thousand parts of water. If ten litres are so aspirated then at least one part of carbonic oxide is present in ten thousand parts of gas if the chloride is reduced to metallic palladium.

4. Dr. Haldane recommends a good method of estimating carbonic oxide in air, which depends upon the following princi-

ple: That when a haemoglobin solution is shaken up with air containing carbonic oxide, the proportion of the haemoglobin which finally combines with the carbonic oxide varies with the percentage of carbonic oxide present in the air. By determining calorimetrically the proportion of haemoglobin which has combined with the carbonic oxide it is thus possible to infer the percentage of carbonic oxide present in the air.

In this brief paper I have endeavored to show you the very dangerous nature of this gas, and its disastrous physiological effects. Practical men like yourselves could, with a little scientific knowledge and perserverance, no doubt, find some satisfactory way of dealing with this gas so as to prevent the many fatal cases which now occur. A good many methods have been suggested by scientific men in the past, whereby these gases may be dispersed or their injurious effects neutralized, but, as a rule, these methods have only been theoretical, and are absolutely useless in practice. In some cases the apparatus which has been suggested to bring about this desired result would itself be blown to pieces by a colliery explosion.

CARBON MONOXIDE IN MINES.

Prepared by request for this report by J. T. Beard, E. M., C. E., and published in Mines and Minerals.

Carbon monoxide is the most deadly gas known to mining, and many miners every year succumb to its effects. Such is its nature that its presence in the mine air is generally unsuspected; this greatly increases the danger from it, and many are overcome by it who are unaware of its presence. The toxic effect of this gas, it should be remembered, is often very sudden, and at times men have fallen as though shot; while at other times there are warning symptoms manifested, and a growing weakness and lack of power in the limbs premonishes the victim of his danger. The cautious, observing miner will heed such a premonition of danger and withdraw to fresh air in time to escape the fatal consequences that are sure to follow the continued breathing of air containing this gas. More often, however, the fear of ridicule prompts men to remain in an atmosphere that they know is dangerous.

In the Zeigler Mine explosion*, at Zeigler, Illinois, April 3,

1905, when 53 men lost their lives, the first rescue party to descend the shaft after ventilation had been restored 10 hours later, consisted of four men. Of these, two, Mine Inspector William Atkinson and Mine Examiner John Graham, dropped suddenly in the main entry, not 100 yards from the foot of the shaft, where they were found three days later. The slight premonitory warnings, if such there were, had been unheeded or unobserved and the result was the loss of two lives.

In the Rocky Fork disaster near Red Lodge, Montana, June 6, 1906, the first rescue party of six men evidently advanced too rapidly for the air and all of them became unconscious at the same time; two of these men were beyond recovery when found by a second rescue party, but four of the party revived when the current of fresh air reached them and were sent to the surface. Eight lives in all were lost through the effects of CO, which in this instance was due to a fire in the No. 6 incline of the Northern Pacific Mine.

All mine gases were formerly known to the miner as "damps." This term has a Dutch or German origin (Dampf, vapor, fumes), and relates to the suffocation that it was formerly supposed all mine gases produced. Later, a distinction was made between the different mine gases, which had previously been regarded as one, and the terms chokedamp or blackkdamp, whitedamp, stinkdamp, firedamp, afterdamp, etc., came into general use to indicate the vary characteristics of these gases, which are now known as carbon dioxide, carbon monoxide, hydrogen sulphide. and methane, respectively; afterdamp is still called by that name, it being the variable mixture of gases resulting from a mine explosion.

Carbon monoxide (CO), or carbonic oxide, as it is often called, is the "whitedamp" of the miners and is the most deadly of all the mine gases. It has no color, taste or smell. Miners are often heard to say they can detect this gas by its "peculiar smell," but this is merely a vagary of the miner, who has many such whimsical ideas that he cannot explain, but in reference to which he is usually very positive.

The gas is somewhat lighter than air, having a specific gravity of .967 hence it tends to accumulate near the roof and in the rise workings. Such are the physical conditions in mines, however, that gases do not travel any great distance except as they

are borne on the air-current circulating through the mine. Consequently, the mine gases, regardless of their specific gravities, are often found in largest proportion where they are generated or issue from the strata. The only exceptions to this rule are marsh gas in a weak air-current, and carbon dioxide or blackdamp, which is often difficult to convey away but tends to settle gradually to the lowest parts of the mine. The results of diffusion are almost wholly confined to a comparatively small area where the gases are formed.

The chief source of carbon monoxide in mines is incomplete combustion due to an insufficient supply of oxygen at the point where the combustion takes place. It is a product of mine fires when the supply of air is insufficient for complete combustion; it is likewise formed in greater or less quantities, depending on the conditions, by the explosion of powder; it is also due to the slow combustion of fine coal, slack, and other carbonaceous matter in the waste or abandoned places of the mine where there is little or no ventilation.

The gas is combustible. It is not an extinctive gas and lamps burn brightly in its presence. The gas burns with a pale blue flame similar to that of marsh gas, but the burning is more quiet than that of marsh gas. The large volume of flame produced by the explosion of black powder, in blasting, is produced by the burning of this gas. What is termed a "windy shot" is due to the firing of a heavy charge of powder under such conditions that a large quantity of fine coal and dust is thrown into the air by the force of the blast, and converted into carbon monoxide by the flame of the shot. The gas thus distilled from the dust increases the volume and intensity of the flame and a local disturbance at the face of a chamber may extend out on the entry or be propagated throughout the mine as a mine explosion, the gas distilled from the fine coal and dust thrown into the air being the chief means of propagation. Under such conditions large quantities of the monoxide (CO) are produced by the reducing action of the incandescent coal dust on carbon dioxide (CO_2); so that the chief product of a dust explosion is almost invariably carbon monoxide and the afterdamp of such an explosion is therefore more dangerous.

Carbon monoxide has a wider explosive range than any of the other mine gases, except hydrogen, as given by the follow-

ing: Lower explosive limit, 1 volume of gas to 13 volumes of air; higher explosive limit, 1 volume of gas to 75 volumes of air.

One of the most dangerous features of this gas lies in the fact that the lamps of the miners continue to burn when the mine air is charged with the gas to an extent that would be instantly fatal to life. The unfortunate victims of this gas have been found with their lamps burning beside them where they lay. The effect of the gas on the lamp is to cause it to burn even more brightly than in pure air. The flame of the lamp reaches upwards in a slim taper blaze. But this is the only indication of the presence of danger and none but the experienced miner is made aware of the same.

Carbon monoxide is an extremely poisonous gas. Its effect on the system is cumulative; that is to say, the poisonous effects produced by even the smallest amounts of the gas are retained for a long time, and continued exposure to an atmosphere containing such small percentages will before long result fatally. The toxic effect of the gas is immediately due to its absorption by the hemoglobin, or colored substance in the corpuscles of the blood, thereby preventing the proper absorption of oxygen or air by these important functionaries of the system. The blood is slow to part with the matter thus absorbed and for this reason very small percentages of the gas in the air when breathed for a considerable time may prove fatal. Ordinarily the statement is made that the presence of .5 per cent of this gas will prove fatal when breathed but for a short time; while 1 per cent of this gas will often cause death in less than a minute. The effect of all poisonous gases, however, depends not alone on the gas itself, but on the depletion of the oxygen of the air. Dr. J. S. Haldane, who has investigated this subject states that when the oxygen of the air has been depleted to 10 per cent, but .05 per cent of carbon monoxide is required to produce fatal results, or 1-10 of the amount required in a normal state of the air.

Average mine air differs from the outer free air of the atmosphere in at least two important respects; namely, the depletion of its oxygen, and contamination with mine gases. The contracted confines of the mine workings do not permit of the revivifying influences that are always at work in the outer atmosphere. Dr. Angus Smith found, as the result of over

300 analyses the following averages of the percentage of oxygen present in samples of air taken from diffierent parts of different mines:

*Mines and Minerals Vil. 25, page 552.

	Per Cent.
Sumps	20.14
Pillar workings	20.18
Working faces	20.32
Shaft bottoms (return)	20.42
Intake currents (inby)	20.65
Large open areas	20.72
Free atmospheric air	20.9

Doctor Smith considers normally pure air to contain 20.9 per cent of oxygen and 79.1 per cent of nitrogen; while he regards air as impure when it contains but 20.6 per cent of oxygen, and very bad when the oxygen falls to 20.5 per cent. The ventilation of mines, however, it is needless to say, has greatly improved since Dr. Smith made the foregoing tests of mine air.

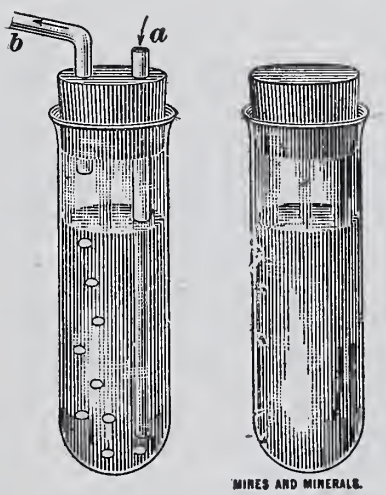
The contamination of mine air with gas is quite generally accepted without dispute.

The fatal effects of carbon monoxide are more quickly experienced by a person with a weak heart. Such a person should never be selected for rescue work, as the excitement always attaching to this work increases the danger. Older men are more susceptible to the effects of gas as a class, than younger and stronger men; animals are more quickly effected than men. Doctor Haldane has found that a mouse will become weak and fall utterly prostrate when exposed to an atmosphere containing carbon monoxide, in about 1-20 of the time the same atmosphere will affect an adult person in good health. He has, therefore, recommended that rescuers and others exposed to such gas carry with them a small caged mouse and observe cosely its actions. The mouse test is now very generally regarded as a safe test for entering doubtful or suspected atmosphere. Mine workings where mice thrive may be assumed to be free from whitedamp. and thus this little pest sometimes becomes a blessing in mines.

Another test is the blood test. This is also the suggestion of Doctor Haldane as the result of his invaluable investigation on the toxic effect of gases. Doctor Haldane argues that since this gas is absorbed by and affects the blood organisms, especially the colored matter of the blood, it is to this the test should be applied to discover the presence of this gas. The test is as fol-

lows: A few drops of defibrinated ox blood are diluted 100 times with pure water, or 3 large drops of human blood drawn by pricking the finger, are added to a fluid ounce of water, making a buff-yellow solution. This solution is equally divided between two test tubes, Fig. 1. The air to be tested for carbon monoxide is then siphoned or drawn through one of these solutions by means of two glass tubes arranged as shown in the figure, the air entering the tube at "a" and bubbling up through the liquid passes out at "b". Air containing but .01 per cent of carbon monoxide will impart a pink hue to the liquid. The pink coloration is best detected by comparing the two tubes, holding a white piece of paper behind them.

The symptoms of poisoning by carbon monoxide when the gas is not present in sufficient quantity to produce almost instant loss of consciousness, are a fluttering sensation at the



heart, called palpitation, growing weakness of the limbs, giddiness, which are followed immediately by unconsciousness and death if the victim is not succored in time. At times the action of the gas is very rapid and promonitory symptoms are very slight or wholly unobserved, and the unfortunate victim becomes unconscious before he is aware of the approach of danger. The blood of the victim to poisoning by carbon monoxide assumes a bright red color after death, and retains this color even on exposure to the air.

Alcoholic stimulants should be avoided in all cases of poisoning by carbon monoxide. Dr. J. W. Thomas recommended a few years ago the forced inhalation of oxygen, and artificial respiration. Of late peroxide of hydrogen, or hydrogen dioxide H_2O_2 has been used with good results. It is important to keep the patient warm and do everything possible to induce a good

circulation. After resuscitation the patient should be put to bed. Rest and quiet are much needed.

The department sent to France for the report of the government commission that was appointed to make inquiry into the disastrous Courrieres explosion of May 8, inst. in which several hundred miners and other underground workers lost their lives, but the report is confined to a rehearsal of the rescue of men and the recovery of the bodies, together with the numerous names of those who took part in the supervision of the work, and there is little of value, from a practical standpoint, in it. It is evident, however, that almost all of the deaths were the direct result of carbon monoxide poisoning, the report saying that from the declarations of the men who escaped the disaster and by all competent persons in the vicinity, that the principal passages of the mine, after the explosion, had been traversed either by flame or irrespirable gases, and all of the first attempts at rescue were prevented by encountering carbon monoxide in such quantities as to incapacitate the rescuers. Some of the bodies that were brought to the surface many days after the occurrence of the disaster, had the appearance of such recent death that criticisms compelled an autopsy, the report of which was as follows: "We find that these men were first of all burnt, and that death ought to be attributed to carbon monoxide poisoning. The state of the burns, which show no sign of having begun to heal, well indicates that death was not subsequent to March 10th. * * * In a general way if many of the men succumbed to the flames, it is certain that many others were poisoned by carbon monoxide or asphyxiated by carbonic acid, some at the very place where they were working, others when seeking safety in flight. * * * The men who thus succumbed for the most part calmly slept in death * * *"

INVESTIGATION OF MINE AIR.

In the "Investigation of Mine Air," by Sir C. Foster and J. S. Haldane, the authors say: While carbonic acid is the product of complete combustion of carbon, carbonic oxide (or carbon monoxide) is formed by its incomplete combustion. It is nowhere found in nature, but it is produced wherever carbonaceous sub-

stances are burnt with an insufficient quantity of air, or when carbonic acid comes in contact with red-hot coal, which takes from it one part of its oxygen. These two processes of formation take place according to the following equations:

$$2C+O2=2CC$$
$$CO2+C=2CO$$

The formation of carbonic oxide in the second way may be observed in every fire place. The tongues of blue flame on the surface of the red-hot coal are due to burning carbonic oxide; the carbonic acid produced in the excess of air in the lower part of the fireplace is reduced to carbonic oxide as it passes through the upper layer of red-hot coals. It is likewise formed by the dry distillation of coal, and is consequently an integral constituent of illuminating gas, which may contain as much as ten per cent of it.

It has never been proved with any certainty that carbonic oxide is a normal constituent of mine gas. It is found, however, oxide is a normal constituent of mine gas, as indeed in all smoke and its percentage increases in proportion to the amount of fresh air supplied to the fire decreases. It also forms a constituent of the after-damp produced by an explosion of fire-damp, when the percentage of methane exceeds 9.5, because then the proportion of air no longer suffices for the complete combustion of the methane. Such explosions are very rare, and in spite of this carbonic oxide is an almost invariable constituent of after-damp, because coal dust has taken part in the explosion. In a case of this kind the carbonic oxide may have arisen either from the dry distillation of particles of coal, in consequence of the heat evolved by the combustion of the gas, or by the incomplete combustion of the distillation products so generated.

Carbonic oxide is a colorless and inodorous gas with a specific gravity of 0.967; one litre of it under normal conditions weighs 1.251 grammes. It is much less easily liquified than carbonic acid. Its critical temperature is about 139.5 degrees C., below which it is converted by pressure into a colorless liquid which boils at 190 degrees. If the temperature is lowered to 207 degrees, it solidifies into a transparent substance. Carbonic oxide will not support combustion, but itself burns with a pale-blue flame to carbonic acid, and with great development of heat.

$$2CO+O\text{-}2=2CO\text{-}2.$$

It constitutes a main ingredient of the so-called producer gas,

which is formed by the incomplete combustion of coal in a special furnace—the producer.

Two volumes of carbonic oxide require for complete combustion 1 volume of oxygen or 5 volumes of air. Mixed with oxygen or air, it forms explosive mixtures, which can be ignited even by a redhot wire.

At the ordinary temperature carbonic oxide exhibits few active chemical properties. It combines neither with gases nor with acids, and has but little affinity for other substances. It is absorbed by the solutions of certain salts with formation of unstable compounds. The best absorbent is cuprous chloride, which is employed dissolved either in hydrochloric acid or ammonia. One molecule of cuprous chloride is capable of combining with one molecule of carbonic oxide, as shown by the following equation:

Cu-2C1-2+Cu-2C1-2CO

Carbonic oxide is extremely poisonous. It has an extraordinarily strong affinity for the haemoglobin, which imports to the blood a striking bright red color. Blood containing carbonic oxide gives a spectrum with very characteristic absorption bands; these may be employed as a means of detecting the carbonic oxide if diluted blood saturated with the gas under investigation is tested spectroscopically. As the affinity of carbonic oxide gas for haemoglobin is 250 times as great as that of oxygen, the blood becomes saturated very quickly, even if the air contains only a small percentage of carbonic oxide. The blood is then no longer able to take up any oxygen, and the person dies of suffocation. When an atmosphere contains only about 0.1 per cent, the carbonic oxide and oxygen enter into a state of equilebrium in the blood, and persons suffer from headache and loss of power in the lower limbs, but do not lose consciousness completely. Even after persons have been a long time in the atmosphere of this kind, they still may be rescued if they are made pletely. Even after persons have beene a long time in the atlow the blood to free itself of the gas. If the atmosphere contains a high percentage of the carbonic oxidee, the blood becomes very quickly saturated with it, and death ensues. The highest allowable limit for carbonic oxide in the air is 0.05 per cent. Unfortunately, at the present time we possess no reliable, practical method of determining such small proportions of the gas,

especially when other combustible hydrocarbons, such as methane, are present.

As a protection against possible poisoning by carbonic oxide, when penetrating into after-damp or gases from underground fires, a live mouse should be carried in a cage as it will show symptoms of poisoning much sooner than a man.

DETERMINATION OF CARBONIC OXIDE.

Simple methods of determining small percentages of carbonic oxide have, unfortunately, yet to be discovered, and it is rarely that largish proportions of this gas have to be determined in the mine air. However, the case arises in testing after-damp, or the gases produced by underground fires.

The absorbent employed is an ammoniacal solution of cuprous chloride, which Winkler prepares as follows: 250 grammes of ammonium chloride are dissolved in 750 c. c. of water; the solution is put into a bottle; 200 grammes of cuprous chloride are added and the bottle closed with an india-rubber stopper. By frequent shaking, this dissolves almost completely, giving a brownish solution which keeps good for any length of time in a closed vessel, provided a piece of copper wire twisted into a spiral is placed in the bottle and made to reach from the bottom to the top. Before use, a third of its volume of concentrated ammonia solution must be added to the liquid. In determining carbonic oxide Hempel's apparatus is employed. As the ammoniacal solution becomes oxidised by the oxygen of the atmosphere, it is placed in a compound pipette. In charging the pipette, 50 c. c. of concentrated ammonia solution are first introduced into the bulb by the aid of a funnel and india-rubber tube, and then 150 c. c. of the cuprous chloride solution are added. 1 c. c. of this ammoniacal solution is capable of absorbing 16 c. c. of carbonic oxide. As the solution after frequent use absorbs very slowly it is advisable to recharge the pipette pretty often; it is possible without any great waste of material, as determinations of carbonic oxide at mines will rarely have to be made. As the ammoniacal cuprous chloride solution also absorbs oxygen and carbonic acid, these two gases must be removed before testing for carbonic oxide. If there is a suspicion that a sample of mine air contains carbonic oxide, the carbonic acid is first

determined by potash solution, then the oxygen by absorption with phosphorus or pyrogallic acid, and finally the carbonic oxide by ammoniacal cuprous chloride.

CARBONIC OXIDE.

This gas is of great importance, from its very serious effect on men; it is often met with in mines and it is responsible for many deaths. CO poisoning is the cause of nearly all the deaths in colliery explosions and in underground fires; and the occurrence of CO in connection with heated coal and the use of unsuitable or improperly handled explosives in ill-ventilated parts of a mine, often gives rise to much trouble. To understand the significance attaching to the presence of varying proportions of this gas in the air, it is necessary to give some account of its mode of action.

The oxygen absorbed by the lungs from the air is normally taken up by the blood in the form of an unstable chemical compound with the red coloring matter (haemoglobin) of the blood, and so carried by the circulation to the tissues, where it is used up. Haemoglobin not only combines with oxygen, but also forms a far less unstable compound with CO; and haemoglobin which is saturated with CO can not take up oxygen. In proportion, therefore, as CO-haemoglobin is formed the blood loses its power of carrying oxygen to the tissues, and death from want of oxygen finally ensues. It will be readily understood, however, that, since oxygen as well as CO has an affinity for haemoglobin, the extent to which the latter substance can become saturated with CO will depend on the relative proportions in which oxygen and CO are present in the air. The one gas tends to drive the other out from the haemoglobin, and the final result is an expression of the balance struck between the two conflicting processes. If the percentage of CO in the air is so high that too little of the oxygen compound is left to support life, then death ensues. If, on the other hand, the person is removed to fresh air before death occurs, then the carbonic oxide in the course of several hours is turned out of the haemoglobin and passes off through the breath; and this process may be greatly hastened by artificial respiration where required, and by the administration of oxygen. If finally, the person remains ex-

posed to a moderate percentage of CO, the blood ceases after a time to take up more CO. In the case of the living body it may be roughly stated that with about .08 per cent of CO in the air the haemoglobin will finally become about half saturated with CO, while with .04 per cent it will become a third saturated, and with .16 per cent two-thirds saturated, etc.

A further point of importance is that with the small percentages of CO which are commonly met with in mines it may take a considerable time for the blood to become sufficiently charged with CO to produce symptoms of poisoning. A man may thus go a long way into a poisonous atmosphere without experiencing any effects; and it may then be impossible for him to return. The volume of blood in a man of average weight has been found to be about three litres, or 5¼ pints, and it is capable of entering into combination with about 600 c. c. (1 pint) of CO. Supposing he is breathing air containing 0.2 per cent of CO, and that he is at rest, when he will only be breathing about seven litres of air per minute, of which only about five litres will reach the air cells of the lungs, he will evidently not be able to absorb more than $50 \times .2 = 10$ c. c. of CO per minute; and it will thus be at the least half an hour before his blood becomes even half saturated with CO. If he is moving about or working he will breathe more air and probably absorb more CO; but in any case it will take some time for the blood to become so charged with CO that he will feel the effects of the poison. In an actual experiment made during rest it was found that with 0.2 per cent of CO in the air the haemoglobin did not reach 50 per cent saturation till after 70 minutes, so that, as might be expected, most of the CO breathed during this period was not absorbed.

The symptoms of CO poisoning are essentially the same as those produced by air deficient in oxygen, and vary according to the degree of saturation of the haemoglobin with CO. With 20 per cent saturation the only symptom is a slight tendency to dizziness and shortness of breath on exertion. As the saturation increases, however, the symtoms of want of oxygen become more and more pronounced, until at 50 per cent saturation it is scarcely possible to stand, and even slight exertion causes loss of consciousness. The onset of the symptoms is very insidious, there being only slight shortness of breath and palpitations, but hardly any discomfort; and the senses, power of judgment and of movement, are commonly much im-

paired before the person is aware of anything being wrong. In some cases there is much excitement, but often there is simple drowsiness and stupidity. The symptoms are in some respects similar to those produced by alcohol. One curious fact is that in CO poisoning, as in alcoholic poisoning, sudden exposure to cool, fresh air may greatly increase the symptoms. Death seems often to be immediately brought about by muscular exertion, as in attempts to escape rapidly up ladders, inclines, etc. If death occurs gradually, the haemoglobin is usually about 80 per cent saturated with CO. In the case of persons who have been rescued alive, but still unconscious, after long exposure to CO, death often occurs later in consequence to damage to the tissues during the exposure.

The dangers of CO poisoning, and the symptoms which accompany it, are reported by Sir Clement Le Neve Foster in his statement of the Snaefell disaster, extracts from which are produced on other pages of this report.

The percentage of CO which is fatal, if sufficiently long inhaled, to men and animals seems to vary a good deal in individual cases. As little as .17 per cent is sometimes fatal to animals, though usually about .4 per cent is required to cause death within a moderate time. Anything above .15 per cent must, however, be regarded as distinctly dangerous, and probably anything above .03 per cent would in time produce symptoms distinctly felt on any exertion.

A miner's lamp, or his senses, will give him warning of the presence in the air of any other dangerous impurity except CO; and in view of the difficulty of recognizing by ordinary means the presence in poisonous amount of this gas, the author proposed the use of a small warm-blooded animal (a mouse or a very small bird) as an indicator of CO. In very small warm-blooded animals the respiration and chemical changes in the body occur far more rapidly than in a man. Consequently, the small animal absorbs CO correspondingly more rapidly, and thus shows symptoms of poisoning much sooner than a man does in the same atmosphere. Hence, if a miner going into air containing CO, carries a mouse with him in an open cage, and watches to see whether he shows signs of sluggishness or exhaustion, it will give him timely warning of the presence of a dangerous amount of CO. It must, however, be borne in mind

that this test is not a very delicate one. Symptoms sufficient to cause in a man diziness, etc., on exertion, would hardly be observed in a mouse; and consequently much caution is necessary in going down ladders, steep inclines, etc., when trusting to the indications of a mouse, as the exertion in returning might produce serious symptoms if even a moderate percentage of CO were present.

A mouse may also be used for detecting the presence of even very small percentages of CO in mines. If it is left for about ten minutes at the place where the air is to be tested, and is then killed at the same place, one can tell approximately by an examination at the surface, of its blood, how much CO was present in the air. A very dilute solution is first made of normal blood, which may be obtained from a prick in the finger. This is placed in two test tubes of equal diameter, and should be of such a dilution that the solution has a yellow tinge. The solution in one of the test tubes is then shaken up with ordinary lighting gas till the haemoglobin is saturated with CO, when its color changes to pink. A preliminary experiment will readily decide whether the solution is sufficient to show fully the difference in tint. In another test tube of the same diameter is placed a solution of the mouse's blood, a drop of which may easily be obtained by opening the heart, and this solution is cautiously diluted until its depth of tint is the same as that of the other two solutions. On now comparing the tints of the three tubes, it will be found that that which is saturated with CO has a full pink color, which contrasts markedly with the yellow of the normal blood solution. If CO was present in the air the blood solution of the mouse will be intermediate in tint, and it is possible to estimate roughly, according as the mouse's blood solution approximates in tint to the one or other of the two first solutions, to what extent the mouse's haemoglobin was saturated with CO. The tints should be compared by holding the test tubes against the light from the sky, and they should be changed from side to side during the comparison.

The following excerpts relative to carbon monoxide, its detection, identification, treatment for prostrations, and evidence in diagnosis, are taken from an exhaustive report made by John Haldane, M. D., for the government of Great Britain:

To understand the dangers to life after a colliery explosion, and the possibilities of escaping these dangers, it is necessary

to have a clear idea of the action both on men and lamps, of the gases which are likely to be present in the air of the mine. These gases, so far as is known, are carbon dioxide, carbon monoxide, nitrogen, fire-damp and sulphurous acid. Oxygen may be deficient or absent. * * * The presence of carbon monoxide in the after-damp, was certainly not an exceptional fact. Such evidence as I have been able to collect from records of explosions, and from those who themselves have been in after-damp, seem to point directly toward carbon monoxide being present in dangerous amount in the after-damp of all great colliery explosions. * * * Rescuers have often been seen to fall over while their lamps were burning brightly and giving no indication of any kind of gas being present, and bodies have often been found beside lamps in which the oil had been exhausted, as if it had burned itself out after the men were dead, and these observations lead to the conclusion that carbon monoxide was present. * * * There seems to be little doubt that in great colliery explosions the immediate cause of nearly all the deaths is carbon monoxide poisoning, and it is of great importance to obtain some rough ideas as to the percentage which may be present in the undiluted after-damp. * * * This gas is present in after-damp, smoke and "gobstink" (i. e., the mixture of gases given off from coal which has spontaneously heated). It differs from other gases in its particularly slow and insidious action, and to render this action intelligible, some explanation is necessary. The oxygen absorbed from the air in the lungs is normally taken up by the blood in the form of a loose chemical combination with the red coloring matter (haemoglobin) of the corpuscles, and so carried by the circulation to the tissues, where it is used up. The haemoglobin not only combines with oxygen, but also forms a much more stable compound with carbon monoxide, and haemoglobin which is saturated with carbon monoxide cannot take up oxygen. Hence, when the blood of a living animal is saturated with carbon monoxide no oxygen can be conveyed by the haemoglobin from the lungs to the tissues, and death must occur from want of oxygen. Carbon monoxide has no other effects than those caused by interference with the oxygen supply to the tissues. Apart from its property of combining with the haemoglobin it is a physiologically indifferent gas like nitrogen. The symptoms produced by it are therefore essentially the same as those described above as

due to partial or complete absence of oxygen in the air breathed.

The key to the peculiarly insidious action of carbon monoxide is afforded by the following two facts: (1) The affinity of carbon monoxide for haemoglobin is a very powerful one, so that when even a very small percentage of it is in the air, absorption by the blood may go on steadily, though slowly, until finally the oxygen carrying power of the haemoglobin is reduced to a dangerous extent. (2) The symptoms produced by deficiency in the oxygen supply to the tissues are very slight up to the point where there is loss of power over the limbs. When the limbs completely fail, it is impossible for a man to get out of the dangerous atmosphere.

The affinity of carbon monoxide for the haemoglobin is about 250 times as great as that of oxygen. In other words the haemoglobin of the blood brought in contact with air containing about 0.1 per cent of carbon monoxide will finally become equally saturated with carbon monoxide and oxygen. If the same blood be afterwards brought into contact with fresh air, constantly renewed, the carbon monoxide is gradually driven out. This process of driving out occurs about five times as fast in pure oxygen (which contains about five times as much oxygen as air). When the blood of a living body has become about 50 per cent saturated with carbon monoxide there is a loss of power over the limbs.

These facts make it possible to understand the process of gradual poisoning, or of the recovery in fresh air. With less than 0.1 per cent of the gas in the air the blood does not become more than 50 per cent saturated, so that even a prolonged exposure does not cause complete helplessness. With 0.2 per cent the blood will become 67 per cent saturated, and complete helplessness, with loss of consciousness, would doubtless occur. Probably this percentage would finally cause death from the gradual damage caused by the diminished supply of oxygen to the tissues. 0.30 per cent would certainly cause death in time.

It is of great practical importance to know the times required for dangerous symptoms to develop in atmospheres containing carbon monoxide, as the necessity often arises of going temporarily, for rescue or other purposes, into such atmosphere. The time required may be roughly calculated as follows: The blood of a man will take up about two pints (1.1 litre) of car-

bon monoxide or oxygen. Hence about one pint of carbon monoxide must be absorbed to produce half saturation of the blood. A man at rest breathes about 10 to 12 pints of air in a minute, and experiment shows that of the carbon monoxide inhaled. about 60 per cent is absorbed. Suppose, therefore, that the air contained 0.1 per cent carbon monoxide, he would absorb about 7-1000ths of a pint per minute. It would thus take him nearly 2¼ hours to absorb a pint. A man who is walking, however, breathes about three times as much air as a man at rest. Hence he might perhaps absorb a pint in an hour. With 0.2 per cent carbon monoxide, the time would be half as long, with 0.3 per cent a third as long, etc. For a man who had already been in the poisonous atmosphere, and whose blood had not recovered, the interval of safety would be correspondingly less than in the case of a perfectly fresh man. Hence, in any case where it is necessary to work in an atmosphere suspected of carbon monoxide, men should, so far as possible, be kept in reserve in fresh air. The whole party advancing together, none may escape.

The danger of advancing far along passages containing afterdamp, smoke, gobstink, etc., is very evident, since a man may go a long way before he feels the effect of carbon monoxide, and when he does feel them he may be quite unable to escape.

Certain symptoms occur before the stage of complete helplessness is reached, and these symptoms should be carefully noted. The first and most important signs of the accumulation of carbon monoxide in the blood are dizziness and weakness of the legs, dimness of sight, and palpitation following any extra exertion, such as lifting a heavy weight, ascending a steep incline, or running. These symptoms become quite distinct when the blood is from 25 to 30 per cent saturated. As the saturation increases, the symptoms become more and more marked, until finally, at about 50 per cent saturation, the limbs are so weak that any effort to walk causes them to give away entirely.

Very little actual distress accompanies the action of carbon monoxide. After paralysis of the limbs the senses become more and more benumbed, as by a gentle anaesthetic. If the percentage of carbon monoxide is large (more than 1 or 2 per cent) loss of consciousness is followed by convulsions, etc., as in suffocation from rapid deprivation of oxygen. If there is less than 1 per cent of carbon monoxide, death is very gradual

and peaceful. The positions in which bodies are often found after an explosion shows clearly that this is actually the case.

Men have for some time been unconscious from carbon monoxide poisoning, or, what is essentially the same thing, want of oxygen, but who have afterwards been rescued, may suffer for many days or weeks from after-symptoms of a most formidable character. A man who has only been partially disabled by carbon monoxide, or who has only been helpless or unconscious for a short time, will usually recover completely within a few hours. Recovery is accompanied by a severe headache and often by nausea and vomiting. The headache and nausea seem to be the more severe the longer the exposure. I have found that an exposure of several hours to as little as .07 per cent carbon monoxide will cause not merely dizziness, etc., on exertion at the time, but a headache afterwards, lasting for about twelve hours. From experiments on myself I calculated that about six hours are required for the carbon monoxide to disappear from the blood in severe cases of poisoning. In the case of one rescued man, I examined the blood about 24 hours after his removal from a pit, while he was still absolutely helpless and almost unconscious. No carbon monoxide could be detected with the spectroscope. He was found still alive beside the bodies of several other men who had died of carbon monoxide poisoning. It seems probable that after an hour or two in the fresh air so much of the carbon monoxide will have left the blood that the normal oxygen supply to the tissues will be re-established. The mistake is often made of attributing what are really after effects to the continued presence of carbon monoxide in the blood.

In more severe cases recovery is much less certain, is very gradual at the best, and is accompanied by symptoms indicative of serious damage to the nervous system has sustained during the period of deprivation of oxygen. Consciousness is for a long time absent. The breathing may be shallow and irregular, or deep and stertorous. The pulse may be almost imperceptible at times. The temperature frequently rises after a time to 103 degrees or higher. There are usually signs of very abnormally increased reflex excitability of the trunk and limbs, the least attempt to move the arms, legs or body giving rise to violent contractions of the muscles, or even to epileptiform seizures. The latter may even occur spontaneously. These symptoms re-

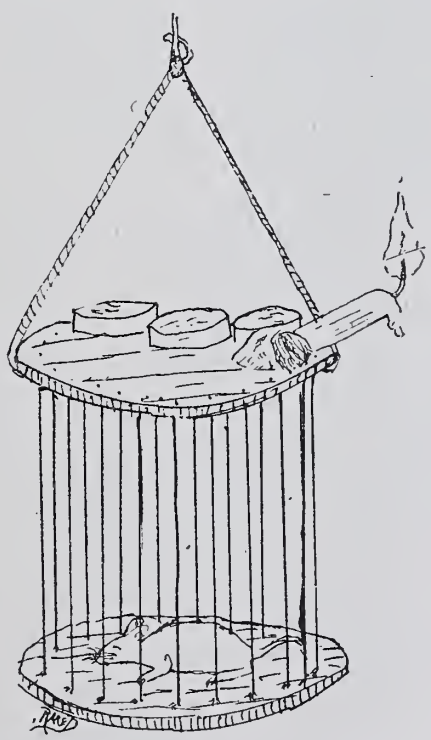
semble very closely the effect of strychnine poisoning.

As regards the treatment of carbon monoxide poisoning, there is no doubt that just at first the administration of oxygen would be of service in rapidly clearing the blood of carbon monoxide. In the pit, however, oxygen will not be available unless special apparatus has been provided for rescue purposes, and by the time a man has been brought to the surface, oxygen will probably be of little use. If the air be not free of after-damp, the man should be removed at once to a safe position. Artificial respiration should be employed as long as the breathing is at all shallow or irregular. If the pulse is feeble, stimulants should be given. Hypodermic injections of ether are found to be of great service. The first effect of cool, fresh air seems, for some reason or other, to be somewhat dangerous. It has been noticed that after an explosion, men rescued seem to lose consciousness on being brought to the fresh air, and that in dealing with gob-fire men who were affected by the gas from the heated coal immediately got worse, or even lost consciousness, if they went into the intake airway to rest. And from the symptoms in these cases, there could be no doubt that the poisonous gas was carbon monoxide. The explanation of the bad effect of the current of cool air (the airway temperature being about 10 degrees F. lower than the level where the men had been working) is not altogether clear. Possibly the cold in some way diminishes the supply of blood to the brain, or perhaps the temperature of the body is reduced owing to impairment of heat producing or heat-regulating functions. The application of artificial warmth is probably often a matter of much importance at first in the treatment of carbon monoxide poisoning. The employment of hot water bottles and blankets seems to be of great service.

The treatment in their own houses of the men who have gotten out of a pit alive after an explosion, is often very difficult on account of the absence of skillful nursing. The chances of recovery are certainly much diminished. It is of great importance that everything should be done to meet every symptom, such as rise or fall in temperature, as it arises, and to promote rest, and thus to give the injured nervous system the best chance of recovery. Every injury should be attended with special care and every source of disturbance or discomfort carefully avoided or removed. It is to be feared that many men who have been

rescued from explosions have afterward died from want of proper nursing.

The recognition of carbon monoxide in the air of mines is a matter of much practical importance, and many lives have been lost through ignorance of the fact that the lamps, upon which miners trust for the recognition of other gases, give no direct indication of carbon monoxide. Like other explosive gases, it shows a cap on an ordinary flame if present in a higher proportion than about one per cent; but in after-damp and gob-stink, carbon monoxide always occurs in combination with such an excess of nitrogen that the lamp is extinguished before it can show a cap. More than 16 per cent of after-damp, or about 0.5 per cent carbon monoxide present, a lamp will be extinguished. Hence the indications from the lamp will at least, in such cases, prevent a man from going into an atmosphere which is very rapidly poisonous from carbon monoxide. Nevertheless, it is clear that some better indicator is required. In daylight .01 per cent of carbon monoxide in the air may be detected by the color test; the more practical method, however, is made with a small animal, such as a mouse. * * * Practically



speaking, the condition of a mouse which has been for a very short time in poisonous percentage of carbon monoxide, indicates what will be the condition of a man carrying it after a much more prolonged stay in the same atmosphere. With a man at rest it takes about 20 times as long for the man as for the mouse,

to be distinctly affected by the gas. Experiments have demonstrated that with .4 per cent, a mouse is distinctly affected in 1½ minutes and quite helpless in three minutes, while the man is not distinctly affected until after a half hour. Experiments in this line have shown how valuable the indications given by a mouse, or other small animal, is to men exposed to danger from after-damp. The mouse may be carried in a small cage, or lamp chimney closed at the ends with wire gauze. When dangerous percentages of carbon monoxide are encountered, the mouse will begin to pant, and to show signs of weakness in the legs; should the mouse suddenly become unconscious, danger is imminent.

The following paragraphs show the the effects of different gases on men and lights. Except in the case of the figures for oxygen, the percentages indicated are percentages by volume in a mixture of the gas and pure air. The figures for oxygen represent the percentages of oxygen present in a mixture of air and pure nitrogen—or air partly deprived of its oxygen:

Oxygen—17.3 per cent, there is no effect on man, but lights are extinguished, and, of course ,extinguished in all of the following lower percentages; 12 per cent, breathing slightly deeper; 9 per cent,, breathing deeper and more frequent, face bluish; 5 per cent, loss of consciousness and final death; 0 per cent, death with convulsions.

Carbon Dioxide—3.5 per cent, breathing deeper, lights burn: 6 per cent, marked panting, lights burn; 10 per cent, severe distress, lights burn; 15 per cent, partial loss of consciousness, lights extinguished; 25 per cent. final death.

Carbon Monoxide—.05 per cent, after half an hour or more, giddiness on exertion; .1 per cent, after half an hour or more, inability to walk; .2 per cent. after half an hour or more, loss of consciousness, and perhaps final death; 1 per cent, after a few minutes, loss of consciousness and final death.

Black-damp (containing 87 per cent nitrogen and 13 per cent carbon dioxide)—16 per cent. no effect on man, extinguishes light, as do all the higher percentages quoted; 28 per cent, breathing slightly deeper; 50 per cent, severe panting; 66 per cent, life endangered.

Fire-damp or Methane—One per cent, no effect on man, first indication of a cap; 2 per cent, no effect on man, well formed

cap; 5.5 per cent, no effect on man, lamp fires and goes out; 45 per cent, breathing slightly deeper; 70 per cent, life endangered.

After-damp (containing 3 per cent of carbon monoxide)—2 per cent, after half an hour or more, slight giddiness on exertion, no effect on light; 3.5 per cent, inability to walk, no effect on light; 7 per cent, loss of consciousness, no effect on light; 10 per cent, death, light burns dimly; 16 per cent, death, light extinguished.

If the pure after-damp is diluted with from 50 to 80 per cent of air, the mixture thus formed will not contain more than about 1.5 to .6 per cent carbon monoxide. The distribution of the saturated blood in the blood vessels seems to correspond well with this conclusion. It has been shown that in rapid death from poisoning by relatively large percentages of carbon monoxide, the blood of the spleen does not show the presence of carbon monoxide when examined with the spectroscope. Death produced in this way is thus so rapid that, as in suffocation by coal gas, the venous blood has not time to become saturated with carbon monoxide. The sudden deprivation of oxygen, caused by the carbon monoxide poisoning, leads to reflex blocking of the circulation, just as in suffocation caused by simple deprivation of oxygen; and this blocking keeps the venous blood from becoming highly saturated with carbon monoxide before death. * * * In a sample of venous blood the saturation was 79 per cent. This is very high and such as one could only expect to find in cases where a very low percentage of carbon monoxide has caused death. Death was known to have occurred in a very dilute after-damp, and the body was lying beside a lighted lamp, and not in the immediate track of the explosion. In another case where the body was directly in the track of the explosion, the saturation was just the same, showing that the percentages of carbon monoxide in the air can hardly have been very different in the track of the explosion and in the place where the lamps still burned in the poisonous air. * * * In the case of horses examined, the saturation of the haemoglobin with carbon monoxide was very high, and exactly the same in the right and the left ventricles. This fact seems to afford strong evidence that death took place in air containing a very low percentage of carbon monoxide.

The following is the summary of the post-mortem appearances of fifty-seven bodies examined where death had been caused by carbon monoxide poisoning. The chief characteristics are a pale skin, and the tongue, lips and nails are a pale pink. In cases where the body was directly in the track of the explosion, there was more or less scorching and redness of the face and body, and where there was probably asphyxia from a deficiency of oxygen along with the carbon monoxide poisoning, the tongue protruded and was bluish and the veins on the upper part of the chest were distended and a reddish-blue.

Nearly everything that can be recommended to be done towards limiting the loss of life in mine explosions must depend for success on previous preparation and organization. The first matter to attend to on the part of those above ground is to get fresh air into the pit as soon as possible. The facts brought to light in investigations show clearly that a very small proportion of those who perish in an explosion are killed instantaneously. According to calculations an hour probably elapses in most cases before even the men lying along the course of the explosion are dead. It is thus evident that anything that can be done within this interval towards clearing away the after-damp may be the means of saving many lives.

The saving of life after an explosion depends, not merely on the action of the rescuers, but still more on that of the men in the pit themselves. At the least warning of approaching flame or disturbance, a man should at once fall flat. In this way both burning and violence may be partly or completely avoided. Moreover, the air along the floor will be cooler and contain less after-damp, and when fresh air comes it will first come along the floor. Any exertion will, by causing the respirations to become quicker and deeper, hasten the action of the after-damp. For a man near the shaft, the best plan probably would be to lie still. For a man near a road, far in, the most hopeful way of escape, if consciousness remains, would be towards a return airway, or towards the face. Those at the face or on roads not traversed by the explosion, should not on any account hurry towards the shaft or haulage roads. To do this will entail almost certain death if the explosion has traversed any part of the road towards a shaft, and even, if this has not been the case, after-damp may have been blown by the force of the explosion into

some part of the road. Any attempts to reach the shaft should, therefore, be made with the utmost caution, and when after-damp is met, the only safe course is to retire again into the fresh air. The after-damp can be detected by its smell and its irritating effect upon the eyes, and any mistiness or unusual warmth in the air should be regarded as a sign of its presence. It should be remembered that the more time can be gained by retiring before the after-damp, the greater chance there will be of its clearing away, or becoming so dilute as to become harmless. There is no doubt that hundreds of men have lost their lives by hurrying blindly towards the shaft, or by not retiring towards the face when they met the after-damp.

In his official report of the investigation he made into the Snaefell, Isle of Man, disaster, in which twenty men met their death through the inhalation of carbon monoxide gas, A. E. Miller, M. B., says: At 6 a. m., 31 miners went down the ladders of the main shaft of the coal mine, in complete ignorance that anything had taken place; no one at the surface had the slightest suspicion of the tragedy that was taking place under ground, until an hour later some of the miners returned to the surface, all of them in an exhausted condition. Assistance was immediately summoned, and I reached the mine at 8:30, and found that but eight of the men had returned from the mine. None of these men who had reached the surface by their own exertions presented any symptoms of note other than the weakness of their lower limbs. The men stated that they had not noticed anything unusual in the shaft until they had descended a considerable distance below the 60-fathom level, when some thought they detected the odor of "singeing"; but as there was no smoke and as their candles were burning brightly, they continued to descend until they were warned by some of the men lower down the ladders. On commencing to ascend they found that they had great difficulty in climbing; their legs gave way at the knees and they suffered from extreme palpitation of the heart and breathlessness. The more they hurried, the more these symptoms were pronounced, till they were forced to rest. While at rest they did not experience much discomfort, with the exception of a feeling of weight over the cardiac region, and there was extreme disinclination to further exertion. In their jour-

ney upwards, some of them had passed their comrades, who were either clinging to a ladder unable to climb further, or were resting at one of the landings, too worn out to continue the struggle toward the surface. The younger and more robust men seemed to suffer more than the older men. Of the eleven men who either reached the surface through their own exertions or were rescued alive, the large majority were men of middle age and over, while the nineteen who were dead when discovered were mostly men under 30 years of age. This is to be explained by their relatively greater activity. On alarm being given they would naturally begin climbing the ladders at a very rapid rate, passing many of those who eventually reached the surface alive, only to be repassed by those who had been obliged to be more leisurely. The effect of the rapid motion would be to greatly accelerate the respiration and action of the heart, and would consequently absorb much more of the poisonous gas in a given time, so that when they sank exhausted, they were too far gone to make any further effort to save themselvs.

One miner, aged 50, dragged up the ladder by means of a rope, arriving at the surface at about 10 a. m., was in a very exhausted condition, though not unconscious. He could neither walk nor stand without support; he was moaning and his mind was muddld; he was offered a stimulant but on taking the glass did not know what to do with it; he complained of being cold and had to be prevented from going into an open fire before which he had been placed. His skin was pale, his lips livid, there was no pulse, and faint heart-sounds could just be detected with the stethoscope. Breathing did not seem to be impaired, but was somewhat hurried. The pupils were dilated, but reacted to light. In the course of some minutes there was free vomiting, and this brought relief. After remaining for some hours in a warm room the man recovered sufficiently to go home, but the pulse was still almost imperceptible. A couple of days later the miner was little worse for his experience, with the exception of a weakness of the lower limbs and some headache.

Another miner, aged 70, was brought to the surface at 4 p. m. and was immediately placed in a temporary hospital. He was unconscious, skin deathly pale and cold, lips livid, no pulse, very faint heart could be heard with the stethoscope. Breathing was stertorious, and with much frothing at the mouth. Pupils

dilated and would not react to the light; conjunctival reflex absent. There was considerable rigidity of the muscles, especially of the arms, which were tightly crossed over the chest and could not be moved even when considerable force was used. He was given a hypodermic injection of ether and hot water bottles were applied to the abdomen and feet. At 6 p. m. he was in much the same state, though the breathing was a little less stertorious and the pupils of the eyes not so dilated; but there was no pulse and the muscles remained very rigid. At 8 p. m. the man was partially conscious, muttering to himself, and his limbs jerked about so much that he had to be forcibly held in bed; conjunctival reflex was present and the muscles contracted. The muscular rigidity had almost disappeared and the patient was able to swallow a little fluid, which, however, was not retained. The skin was warm and the color much improved, but still no pulse was perceptible at the wrist, although the breathing was quiet and natural. At 10 p. m. he was conscious, though much confused, but was unable to sit up. The effort to pass water was difficult. The pupils had become normal and there was a slight pulse perceptible at the wrist. He passed a good night, with the exception of a constant desire to empty his bladder, and there was considerable difficulty in micturition. He was practically recovered in a few days.

The third man brought up, arriving at the surface at 4:30 p. m., aged 44, exhibited symptoms corresponding exactly with those of the previous case, except that he was more profoundly unconscious and his breathing, though stertorious, was shallow and irregular. The same treatment was adopted as in the previous case, but at midnight there was no change in his condition and he remained entirely unconscious. At 10 o'clock the next morning he was still unconscious and pulseless, though there was improvement in breathing. The skin was getting warm and the color was returning. The pupils were still dilated and there was no conjunctival reflex. With a catheter about ten ounces of apparently normal urine was drawn and a rectal injection of egg and brandy was given. At 8 o'clock that evening his temperature was 100 degrees and the skin warm and moist, breathing quiet and regular, but still no pulse, and the pupils were not quite so dilated. The urine was again drawn and the rectal injection repeated. The next morning, though

unconscious, he could be partially aroused. There was a faint pulse, the temperature was 101, and there was free respiration, and breathing was strong and regular. There was a considerable amount of crepitation over the base of both lungs. The pupils at this time were abnormally contracted and conjunctival reflex present. During the day the patient regained consciousness and was so restless that he had to be held in bed. He was nauseated and the matter raised contained altered blood. He was able to swallow a little liquid. At 8 p. m. he could be roused easily; his temperature was 102; breathing rapid and difficult; pulse somewhat stronger though still thready and fast; perspiring freely; muscular rigidity had disappeared. The morning of the fourth day, the patient was entirely conscious and complained of pain in the back and abdomen. The pulse was 120, temperature 101, breathing easier, but dullness over base of both lungs; taking nourishment freely, but required the use of the catheter. In the evening the man was still conscious, but very nervous and disturbed by a cough, and there was considerable expectoration that was slightly tinged with blood; temperature was then 103 and the pulse 130, and the area of dullness over the lungs was considerably increased. All these symptoms increased during the next day, and the following day the patient relapsed into unconsciousness and died early the next morning of acute pneumonia—the sixth day after being brought up from the mine.

The fourth man rescued, aged 32, was brought to the surface at 5 p. m. of the day of the disaster, and though quite conscious on arrival on top, he had laid unconscious most of the day at the same point in the mine from which the first and second men rescued were taken. The rescuing party had punched holes in the air pipe that had been passed down the ladderway, and as the air improved about him he gradually recovered consciousness. He looked fairly well, but was cold and pale; the pulse was not perceptible; breathing was natural, pupils normal. He could not remember any of the events of the day, after commencing to climb up the ladders after the first alarm was given, although it is known that he came up a considerable distance before becoming unconscious. He had no recollection of experiencing anything unusual when descending the mine in the morning, and said he only commenced to return on being told to do

so by some of his comrades. By midnight he appeared perfectly well, though he had no pulse, and his color was natural; he experienced considerable difficulty in passing water. The next morning he was feeling well, only complaining of his limbs, which had been bruised in effecting his rescue. His pulse was fairly strong.

In giving a report of the recovery of the bodies of the miners who perished from the poisonous gas, the same authority says that nearly every member of the rescuing party was affected by the gas to a greater or lesser degree, the intensity of the symptoms varying with the length of time to which they were exposed to the influence, and the depth to which they descended in the mine. The deeper they went, the more pronounced were the symptoms, on account of the greater impurity of the air and the larger amount of the gas absorbed by the blood. The first symptom that is generally experienced is severe palpitation of the heart, and this is followed by a weakness of the lower limbs, the latter gradually increasing until one is forced to sit down. If they could then get fresh air from a hole in a compressed air pipe, they would recover sufficiently to allow them to reach the surface. In several instances, however, they became rapidly unconscious and had to be drawn up the shaft in the box that was prepared for the purpose. On arrival at the surface these presented the same symptoms as those heretofore mentioned as being resuscitated, but in a lesser degree, and more readily responded to treatment, recovery being rapid and accompanied with nausea and shivering. These symptoms were succeeded by a period of mental excitement, almost hysterical in its intensity, which was followed by severe and persistent headache. One member of an exploring party, who, though not unconscious when sent to the surface in the box, after being in the open air for an hour, had a true epileptic fit, though he had never previously had a similar seizure. The most constant of the symptoms accompanying carbonic acid poisoning is unquestionably the effect on the heart. In every instance cardiac depression was most marked, and was the last symptom to disappear. This accounts for the great improvement evidenced in all the cases after hypodermic injections of ether, which, together with the external applications of warmth and the enjoinment of perfect rest, in a recumbent position, I consider the essentials of treat-

ment. While artificial respiration is recommended in these cases, it cannot be conceived how it can be performed, on account of the muscular rigidity observed in the more serious forms of carbon monoxide poisoning If the patient can be removed to a pure atmosphere, the breathing can be allowed to take care of itself, as the action of the heart fails before breathing ceases. Three bodies that were recovered late in the evening of the first day and fifteen others on the two days following, were carefully examined. On the three bodies first mentioned there were no marks of violence other than a few superficial scratches. Rigor mortis had set in, and it was peculiar in that the muscles appeared to have passed from their last contraction during life directly into a state of rigidity. The external appearance of the bodies were almost identical in every instance, and were characteristic of death from carbon monoxide poisoning. The peculiarly bright red color of the blood, as seen in the lips and skin of the face and in the palms of the hands, was striking; the expression on every face was calm, peaceful and remarkably life-like. The appearance of the faces recalled that observed in persons with a fair skin, after rapid exertion. This peculiar appearance, due to the color of the blood, evidently persists for some time, as it was distinct on the third day, when decomposition was in an advanced stage, and was yet very evident seventy-two hours after the accident. Unfortunately, permission could not be secured to allow an internal examination of the bodies.

Sir C. Le Neve Foster also made an extended investigation of the disaster and its causes, directly after its occurrence and during the period of recovery of the bodies, and the following excerpts are made from his report, touching points that are not so clearly defined or covered by the report of Dr. Miller:

* * * Three days before the accident, my assistant examined the mine thoroughly and reported to me that the ventilation was very good, and judging by later evidence of miners. things were very much the same the day before the disaster. Writing of conditions after the disaster, he says: * * * With the object of improving the atmosphere of the mine, holes had been punched in the pipes conveying air to the machines, and this gave some relief. * * * Two of a rescuing party made their way nearly to the 100-fathom level, passing other dead bodies, many of which impeded their way. The obstruction of

the manhole just above the 100-fathom level, by three bodies, was so great that they decided to proceed no further; and it was fortunate that they did so, as on commencing their ascent, they found that their strength was failing them and that they experienced difficulty in climbing the ladders. Reaching the others of the rescuing party at the 60-fathom level, they were found to be complaining of weakness and inability to climb. At this crisis a remedy was applied in a fashion hitherto untried in mining accident. After failing to procure cylinders of compressed oxygen, the inspector bought a pound and a half of potassium chlorate, and took it into the mine and made use of it for the benefit of the rescue party at the 60-fathom level. He lighted a heap of newspapers on the floor of the level, and threw the potassium chlorate, little by little, into the flame. On leaning over the fire and inhaling the fumes, the party experienced decided relief and to some extent regained their strength. It is probable that the reflagration of a portion of the chlorate furnished heat enough to cause another portion to give off its oxygen; but be the explanation what it may, the improvised remedy was unquestionably of service in enabling the party to reach the surface. * * * They had descended as far as the platform immediately above the 130-fathom level. One of the miners, kneeling on this platform, put his candle through the manhole, in order to look for the last body, and it was extinguished. Knowing the importance of ascertaining the exact nature of the gas, a note was sent to the surface asking for some bottles, filled with water and well corked. Standing on the second rung of the ladder below the platform, and keeping his head well up, a bottle was held under the platform, the water allowed to run out, and then it was recorked. A second sample was secured in like manner, but while emptying the third bottle, without any warning the inspector became unconscious and the sample was not secured. There is no doubt that the gas was disturbed by taking the samples, and that he inhaled it as it came through the manhole. The effect was instantaneous; but it must be recollected that his blood was previously affected by being in the mine for some hours. As the inspector knew he was running some risk, he had wisely taken the precaution to put a rope around him before undertaking the dangerous task; and if this precaution had been neglected it is almost certain he

would have lost his life. After partial resuscitation at one of the higher levels, he was wholly revived at the surface by subcutaneously injected ether. * * * Being convinced that carbon monoxide was at the bottom of the mischief, I had brought a supply of mice, with the object of employing them as indicators of the poison. A mouse was placed in an improvised receptacle, and a lantern and lighted candles were placed in the kibble with it. With the aid of this testing apparatus it was easily ascertained, and without any risk, that the air was not bad as far as the 115-fathom level, and that it became poisonous and deadly at the 130 fathom level. The mice showed precisely the same symptoms as human beings; as, if not completely dead on arriving at the surface, they had lost all power in their legs, and pinkness of the snout recalled the pink lips of the dead miners.

Dr. Haldane made the following report on the articles sent him for examination, in connection with the Snaefel disaster:

"Mouse lowered into the mine in a kibble as far as the 130-fathom level; came up alive, legs paralzyed, killed on reaching the surface. The blood on dilution with water was found to have a pink tint characteristic of corbon monoxide poisoning. Judging roughly by the tint, I estimated that haemoglobin was about 80 per cent, saturated with carbon monoxide.

"Mouse taken down into the mine and lowered from the platform at the foot of the fourth ladder below the 115-fathom level to a platform some 25 feet below it; mouse suffered and was killed at once. The blood of this mouse had also the characteristic tint of carbon monoxide poisoning. The saturation of the haemoglobin was exactly determined and found to be 78.3 per cent.

"The composition of the sample in the first bottle opened was found to be as follows:

Oxygen	15.48 per cent.
Carbon dioxide	4.22 per cent.
Carbon monoxide	1.07 per cent.
Hydrogen	0.48 per cent.
Nitrogen and argon	78.75 per cent.

The gas in the second bottle had the following composition:

Oxygen .....15.82 per cent.
Carbon dioxide ..... 4.26 per cent.
Carbon monoxide ..... 1.10 per cent.
Nitrogen, argon, hydrogen ....79.12 per cent.

"As the second sample was evidently the same as the first, the hydrogen was not determined separately.

"The carbon monoxide was in each case determined chlorimetrically with blood solution, and the hydrogen by passing over a glowing platinum spiral. The carbon dioxide formed by contact with the platinum corresponded exactly with the carbon monoxide known to be present, so that no appreciable proportion of the methane or other hydrocarbons can have been present.

"The composition of the sample corresponds to a mixture produced by the combustion of wood or other similar material. Inhalation of air of this compound would produce helplessness in a man within about seven or eight minutes at the most, and would soon cause death. A candle would not burn in such air, but would just do so by the addition of a third of its volume of fresh air. The mixture would then be intensely poisonous to life, and would still be if diluted with four times its volume of fresh air. If diluted with nine times its volume of fresh air, it would still be capable of redenring a man incapable of walking.

"Though Prof. Dewar (Recent Researches of Meteorites), Tilden (on gases enclosed in crystalline rocks and minerals), and Bedson (A Contribution on Our Knowledge of Coal Dust), have discovered that carbonic oxide occurs occluded in certain rocks and minerals, the gas has never, I believe, been found as the natural constituent of the atmosphere of mines. * * * I think it is now perfectly certain that the twenty deaths at the Snaefel disaster were due to carbon monoxide, produced by timber burning in the mine. * * * The timber was then burning in a sort of cul-de-sac (at the 130-fathom level) and did not get all the oxygen necessary for a perfect combustion of the carbon, and the result was that carbon monoxide was generated in addition to carbon dioxide. * * * It is rather startling to find how small a quantity of timber need be burnt to fill to a dangerous extent the passages of a mine. According

to Mills and Rowan, air-dried wood may be considered as consisting of—

40 parts of carbon (inclusive of one part ash),

40 parts of oxygen and hydrogen in the proportion in which they unite to form water,

20 parts of hydroscopic water.

Taking the weight of a cubic foot of larch, which was the kind of timber used at Snaefel, at 34.5 lbs., the quantity of carbon in it will be—

$$\frac{39 \times 34.5}{100}$$

$=13.455$ lbs.

Twelve (12) parts by weight of carbon combining with 16 parts by weight of oxygen, will produce 26 parts by weight of carbon monoxide. Therefore one cubic foot of larch will produce—

$$\frac{28 \times 13.455}{12}$$

$=31.395$ lbs.

of carbon monoxide. At a temperature of 60 degrees F., and under a barometric pressure of 30 inches, one cubic foot of carbonic monoxide weighs about 520 grains. Thirty-one pounds of carbonic oxide will therefore occupy 417 cubic feet of space. Taking an ordinary mine tunnel or level as being 7 feet high by 5 feet wide, each yard of length will contain 105 cubic feet, and therefore it is easly to learn by calculation that 417 feet of carbon monoxide will furnish 1 per cent of the contents of a gallery 400 yards long, and 1 per cent of this noxious gas is quite sufficient to cause almost immediate loss of consciousness, followed speedily by death. (Since this report was written, I find that Prof. Ramsey and Mr. Traverse, in their paper on Fergusonite, state that a small quantity of carbonic oxide is given off by the mineral gadolinite when heated, and Behrens notes the occurrence of the gas in the coal of Upper Silecia.)

"The total capacity of all the levels and shafts and excavations in the Snaefell mine, is a little over a million cubic feet, therefore 25 cubic feet of timber contains carbon enough to produce sufficient carbon monoxide to give an atmosphere with one per cent of the noxious gas all through the mine.

"To the query: 'Why did not the men start to climb up the ladders the moment they began to feel the effects of the

poison,' the answer is: Carbon monoxide is a most insidious enemy, as, while it is easy to go on descending ladders while inhaling the poisonous atmosphere, the limbs seem to be incapable of action when the exertion of climbing is encountered."

MEASURES IN CASES OF "GASSING" IN MINES.

The following notes on the subject of "gassing" in mines, are taken from report of the Department of Mines of Western Australia, and are extracts from a paper by Drs. Macaulay and Irvine on Safety Measures in Mining:

"The poisonous gases which arise in our mines and which for practical purposes need here be considered, are CO_2, CO and NO_2.

"CO_2, the 'choke damp' of collieries, arises from a variety of causes in all mines; in metalliferous mines large quantities may result from an accumulation of the gas from complete detonation of nitro-glycerine explosives, which has not been dispersed by adequate ventilation. Poisoning from this gas alone is rare. The presence of dangerous quantities is revealed by the extinction of the flame of a candle.

"CO is produced in collieries as the result of fires or explosions; while in metalliferous mines it results, along with varying quantities of NO_2, from the incomplete detonation or combustion of nitro-glycerine explosives. Poisoning by these gases is very common and frequently fatal. It is necessary, therefore, that miners should be made clearly to understand (1) the precautions which must be taken when persons are about to proceed to places where an accumulation of these gases is suspected, together with the simple means for detecting their presence; (2) the measures to be adopted when cases of poisoning actually occur.

"It should be provided by law that in every mine some kind of safety appliance should be supplied. The safety helmet, very simple in construction, very efficient in action, and not too cumbersome to wear. It possesses the advantages that ordinary atmospheric air is compressed in the reservoir, that it does not require O_2, or any apparatus more complicated than a bicycle pump to fill it. These are made in two sizes and will run from one to three hours.

"Of some such device two at least should be kept on every mine, a single person being useless for rescue work. And it is important that all points respecting the fitting out and performance of rescue work, together with instruction in the use of this or that appliance, should be accurately defined and practiced beforehand. Many of the mines, benefiting by recent experiences, are providing fire plant and appliances and forming their men into an organized fire brigade under the charge of the resident engineer. The fitting out and performance of underground rescue work should naturally form part of the instruction and drill of such an organization.

"With regard to respiration masks generally, it is well known that even men who are skilled in their use are only too prone to open the air inlet valve unduly wide, thus inducing too high a pressure inside the mask, and thereby increasing the difficulty of breathing and necessarily shortening the working period of the apparatus.

"On receipt of a signal that an accident has occurred on a level, this respiration apparatus, together with an O_2 cylinder, should accompany the stretcher equipment. This should always be the rule, as time is only lost in waiting for a detailed account of the nature of the accident that has occurred.

"The second provision that should be made in law is that a supply of white mice should be kept at all collieries. It is well known that these animals are peculiarly susceptible to poisoning by CO, their susceptibility being so great that they can be employed as a reliable test for dangerous quantities of the gas. The respiration exchange is 20 times as rapid as in a man, and consequently the mouse exhibits symptoms of blood saturation much more rapidly. Dr. Haldane proved that with 0.4 per cent CO in the air a mouse gave symptoms of illness—staggering gait—in one and a half minutes, and that it became unconscious in three minutes, whereas he did not feel discomfort for half an hour. This gives a sufficient interval for a miner to escape. Haldane lays down the rule that air must be regarded as dangerous the moment the test mouse becomes incapable of motion. The law should, therefore, provide that whenever there is a suspicion of an accumulation of CO, these animals should be used as a test.

"Nitrous fumes fortunately reveal their presence by their peculiar pungent odor. But there is great and urgent necessity

that mine officials and miners should be made to realize the danger of exposure to even small quantities of these gases; for the reason that exposure to the diluted gases for several minutes may cause little or no initial distress, and yet give rise several hours after, in the fresh air, to the most grave symptoms, ending fatally. For instance, a man under our care, who was not even conscious of having been gassed, developed symptoms of irritant pneumonia which follows inhalation of these fumes, and died after an illness of nine hours. Another of our cases, a contractor, in his anxiety for a big check at the end of the month, disregarded a warning of the shift boss, who suspected burning dynamite, and returned to the drive one hour after blasting. Ten minutes there sufficed to produce a typical illness which nearly cost him his life and enabled us to test the method of treatment which previous less fortunate cases had given the clue. It should therefore be laid down that no man should attempt or be allowed to work in an atmosphere where red fumes are perceptible to the smell. Our experience goes to show that fatal gassing from this cause which has passed unrecognized is more common amongst the unskilled workmen than has heretofore been realized.

"CO_2 is irrespirable and incapable of supporting life; it renders arterial blood rapidly venous, and is in itself a narcotic poison.

"When air contains an undue amount of CO_2, the effects are not very noticeable until the proportion reaches 3 per cent. The breathing then becomes deeper and any exertion causes unusual panting. The depth and frequency of the respiration increase with the percentage of the gas present. At 5 per cent there is marked panting during rest; at 7-8 per cent there is great oppression and greater panting. At 10 per cent the difficulty is very severe. At a slight increase beyond this stage suffocation ensues and consciousness is lost not, however, necessarily with fatal results if the patient is removed to fresh air. It must be carefully remembered that resuscitation is possible long after the stage of insensibility.

"Loss of consciousness is preceded by headache with great pressure in the temples, giddiness, a drowsiness with loss of muscular power, profuse perspiration and nausea, singing in the ear, and a pungent sensation in the nose, similar to that experienced in drinking gaseous drinks.

"A person poisoned presents livid discoloration, especially about the eyelids, lips and throat.

"The amount of CO_2 in air sufficient to extinguish the flame of a candle is variously stated by different observers as from 5 to 17 per cent. It depends in large measure on the percentage of O_2 in the mixture, thus Haldane found that 75 per cent of CO did not extinguish the flame, if the remaining 25 per cent consisted of O_2. In any case it may be laid down as a rule that an amount sufficient to extinguish a flame, will prove a fatal dose to a man.

"CO is colorless, tasteless and inodorless, but combustible gas with a specific gravity of 0.967. Being imperceptible to any of the senses, it is extremely insidious and dangerous. It is a virulent poison, on account of its chemical avidity for hemoglobin, which is stated to be 200 to 250 times greater than that of O_2. Symptoms are produced where 0.05 per cent is present in the air; and fatal results with 0.5 to 1 per cent. With 1 per cent CO in the air, saturation of the blood takes place in not longer than five or six minutes; and when the blood has reached 79 per cent of saturation death is inevitable.

"The symptoms of poisoning with this gas are a feeling of discomfort, with throbbing of the blood vessels, followed by headache, giddiness and great muscular weakness; there may be sickness and vomiting. A drowsy feeling creeps on, gradually ending in unconsciousness. Respiration is accelerated and labored. More or less extended patches of bright color make their appearance on the anterior part of the body. But it is a mistake to look on a poisoned person who is still alive for the red, rosy, healthy appearance which is so characteristic a feature in the dead body on account of the brilliant appearance of COHB blood. On the contrary, in a poisoned person the skin is dusky, and the lips and extremities blue.

"The conditions under which the various gases are produced in the mines render it probable that almost all cases are to some extent cases of mixed poisoning. Yet in practice we find the symptoms of one or the other predominate, sometimes to the exclusion of the appearance of poisoning by any other gas. Thus, poisoning by nitrous fumes has come to be regarded and recognized as a distinct entity, deserving of very careful consideration.

"There is a history in all cases seen alive, of having been, as the miners term it, 'gassed,' i. e., they are conscious of having

been exposed to a vitiated atmosphere: (a) from the smell of the air, (b) from some immediate distress and a longing for fresh air, (c) from a feeling of thirst.

"We have not known of a case being immediately overpowered, and succumbing underground, as so frequently happens with CO and CO_2; and there is no difficulty in effecting an escape. We wish, however, to lay great stress on this point, that the initial distress is not so marked as to give a danger signal to effect an escape as soon as possible. As the period of exposure required to ultimately produce serious poisoning is very short, miners must be trained to recognize red fumes and to appreciate their intensely poisonous nature. In one of our cases where most serious symptoms supervened, the patient was present in a blind end one hour after blasting, for less than ten minutes; and a fatal case is recorded where the fumes of burning dynamite were inhaled for five minutes.

"For a considerable time after removal to fresh air (an interval amounting in some cases to as much as eight hours) there are no noticeable symptoms; and men who are poisoned are able to ascend a mine, wash, change, and partake of their food without conscious discomfort. But when after this quiescent interval the distinctive symptoms supervene, they do so with alarming rapidity. There is first a difficulty in getting wind, followed by so great a distress in breathing as to produce fear of impending death; a cough at first dry, but speedily accompanied by the expectoration of copious, watery, blood-stained mucus. With this there are the feelings and signs of profound collapse. The symptoms are those of an intensely acute irritant oedema of the lungs. Death, which usually takes place in a few hours, may be due to asphyxiation from water-logging of the lungs or to sudden heart failure.

"The insidious and dangerous nature of poisoning by this gas is illustrated by the common history of native cases which have come under our notice. It has been the rule that so little attention has been paid to the amount of gassing they are suffering from, that they are allowed to go to the compounds without any medical assistance; they are usually found dead or moribund several hours afterwards.

"We have also reason to believe that many of the reputed pneumonias which contribute so largely to underground mortality may have their origin in this manner.

"This delay in the development of the symptoms of poisoning by nitrous fumes suggests the first rules we would lay down for systematic adoption in every case of gassing:

"Every case of gassing must be at once reported by the observer to the shift boss, by whom it is to be reported to the manager direct. There should be no relaxation of this rule allowed on a mine, or in any case, however apparently trivial.

"The sufferers must be immediately brought to the fresh air and receive medical attention. All cases must be kept under observation. In an instance with which we had to deal, where the history is very precise, the gassing occurred at 3:10 p. m., when five men were gassed, under the following circumstances: They were working at the end of a drive, at right angles to which, 100 feet or so from the blind end, was a crosscut. By accident the men working in the crosscut blasted their round of holes before the men at the end of the drive had left. These latter were thus imprisoned for three-quarters of an hour by the gases issuing from the crosscut. They felt, as they described it, that they were being gassed, and turned on the full pressure of compressed air to give them fresh air. They had no difficulty when the air cleared somewhat in making their way to the surface, apparently none the worse for their experience. They washed, changed, and proceeded to the mine boarding house for their evening meal, which they partook of heartily. Thereafter they retired as usual to their rooms. Urgent symptoms came on very suddenly at 10:30 p. m., seven hours after the inhalation of the gas. They were seen at 11 p. m., and were then so ill that there were serious doubts as to the possibility of removing them to the mine hospital, less than 300 yards away. In the case of three of these men, natives, who did not receive attention until the next morning, one was found dead, one moribund, and the third very ill and in great distress.

"In another of our cases, the gassing, also as in the above cases, from nitrous fumes, occurred on Friday night. He was brought to the hospital, moribund about 12:30 on Sunday morning. He was very ill on the Friday, his friends thinking he had a bad cold, which they treated in the usual mine fashion, with liberal doses of whisky. He died Sunday morning.

"Having thus emphasized the necessity for reporting cases, however trivial, and of keeping them under skilled observation, we wish, before detailing the systematic measures which should

be employed in every case, to enter a protest against a practice which is only too common, that of treating gassing externally with cold water, and internally with whisky.

"Cold water, liberally applied, is popularly supposed to have a wonderful restorative effect in all kinds of fainting, and is on that account generally used as the readiest and easiest means to overcome the unconsciousness of the victims of gassing.

"Now in any severe injury, whether due to a visible or tangible cause, as physical violence, as in ordinary surgical injuries, or to an invisible or none the less potent cause as in gassing, one of the principal constitutional effects is the condition called 'shock.' Shock is characterized by three important symptoms: (a) weakening of the heart's action; (b) general exhaustion of the nerve centers; (c) lowering of the body temperature.

"These symptoms are present in every case of gassing and the third, the lowering of the body temperature, is particularly noticeable, this being due, not merely to shock, but also to the fact that CO_2 and CO directly, and NO_2 indirectly, affect the oxygen of the blood. Hence it is very obvious that any measure, such as the application of cold water, which will further increase shock and lower the body temperature, must be carefully avoided, and that, on the contrary, every effort must be made to maintain and raise the body temperature. All cases of gassing must be therefore immediately taken to a warm place if at hand and kept warm by the application of warm clothing and other external means.

"The immediate administration of whiskey or brandy, we also deprecate. It has been clearly proved by Mummery (Hunterian lectures, 1905), that alcohol increases surgical shock, and the physiology or shock being the same, whatever its cause, it is certain that it will do the same in shock from gassing.

The necessity of giving this warning against these two venerable customs (which have the authority of nearly every text book) has been frequently impressed upon us. Here, again, it would be easy to multiply instances, but one will make the point abundantly clear. Five miners were badly gassed, the chief poison being CO. They were rescued and brought to the surface. When a medical officer arrived he found them lying in an open shed, unconscious, and friends treating them liberally with douches of cold water and attempting to force whisky down their throats. It was a bitterly cold night and anything better

calculated to increase the shock from which they were suffering, and in the event of their having inhaled any NO2, the risk of pulmonary trouble, it is difficult to imagine. It is also no uncommon experience to find the subjects of poisoning by nitrous fumes, who have been under the solicitous care of friends for several hours, brought to a hospital in an advanced alcoholic condition. In these cases it may safely be said that there is certain death in the bottle.

"The immediate steps to be taken in cases of gassing are as follows:

"In every case of gassing where the act of swallowing is voluntarily if possible an emetic should be at once administered; and for this purpose we recommend that at every shaft a solution of sulphate of zinc, containing 30 grains to the ounce should be kept. This is to be administered in ounce doses every ten minutes until emesis is produced. The advantage of emptying the stomach and of emptying the lungs of mucus, and of any unabsorbed gas in their ultimate recesses, which the act of vomiting does more effectively than any voluntary effort, more than counterbalances the momentary depressing effect of the emetic.

"We recommend that at every pit-head a supply of sal volatile (aromatic spirits of ammonia) be kept, and that a dose of two drachms (two spoonsful in water) be given to every patient who can swallow, immediately after the completion of the preceding maneuver. Ammonia is the only defensible stimulant. It acts more quickly than alcohol, and has chemical reasons in its favor as well.

"At every pit-head or at the mine hospital, when these are within reasonable distance of the workings, there should be kept two cylinders of oxygen with masks. Oxygen should be administered in every case of gassing, and where artificial respiration is required, this should be performed in an oxygenated atmosphere. Mine officials should be trained in the proper and economical use of this simple apparatus. The remarks about unduly opening the air valves of respiration apparatus, apply equally here.

"The value of O2 in poisoning by gases has been abundantly proved. Perhaps in no case is its beneficial effect more marked than in the terrible distress of the pulmonary oedema of nitrous fumes poisoning. Again, it has been found that CO, which has a very strong hold of the Hb of the blood, is eliminated five

times as rapidly in an atmosphere of O2 as in air. The exhibition, therefore, in a concentrated form of this elixir of life not only hastens immediate recovery, but largely helps to obviate the remote ill effects of carbon monoxide poisoning.

"In every case of gassing which is so profound as to cause deep coma and arrest the respiration, artificial respiration must be started immediately, and persevered with so long as there are any indications of life. There must be no delay in thinking of or trying other remedies. It must be remembered that resuscitation is possible long after the stage of insensibility.

Artificial respiration is performed as follows (Sylvester's methods):

"The patient is to be placed flat on his back, with chest and arms bare and all tight clothing opened or removed; the head kept low, the chin being well drawn up, or, preferably, the tongue pulled out with forceps, if at hand; the chin is raised by pad, such as a coat rolled up, being placed under the shoulders. The operator, standing at the head of and looking at the patient, grasps the patient's arms just above the elbows, one in each hand, and draws them with a sweep to above the head, counting 1, 2, 3. This movement expands the chest and air enters the lungs. He then brings them down to the front side of the chest, against which he presses them firmly. At the same time it is very useful that an assistant should press the abdominal viscera upwards towards the diaphragm to complete expiration. After a pause of four or five seconds the movement is begun again, and gone through in the same way. The operation is repeated at the rate of fifteen times a minute; not more. The common mistake made by laymen in performing artificial respiration is in their eagerness and hurry to attempt too many respirations. We have seen as many as 50 to 60 a minute. As soon as the patient commences to make slight, convulsive efforts to himself get his breath, the greatest care must be taken not to interfere with them.

"Great care is required in performing artificial respiration; and it should not be discontinued for an hour if there are any hopes of life. So long as the heart continues to beat, however feebly, there is always hope of resuscitation.

"Poisoning by nitrous fumes, which is much more common in our mines than is generally supposed, and which is caused by

contact with an atmosphere vitiated by the products of combustion or incomplete detonation of nitro-glycerine explosives, has its symptoms so long delayed that the treatment of its chief symptoms falls entirely to the medical officer. But we again repeat the warning about the insidious nature of this poison and the constant necessity of keeping every case of gassing under observation. The initial measures we have recommended should not be omitted in this case also.

"The proper treatment for nitrous fumes poisoning is the immediate and repeated administration of ammonia (in the form of sal volatile, as already recommended), acting both as an antidote and a stimulant. Shock may have to be counteracted by saline transfusions; and should the symptoms of irritant inflammation of the lungs supervene, venesection and liberal bloodletting may have to be performed and oxygen inhalations employed, in conjunction with the above remedies. But these fall within the province of the medical officer. Finally, a knowledge of these simple safety measures should be required of all managers and overseers, be embodied in the mining regulations, and form part of the state examination.

INTERNATIONAL CORRESPONDENCE SCHOOLS AUTHORITIES.

The text books of the International Correspondence Schools of Scranton, Pennsylvania, give the following relative to carbon monoxide:

"It is owing to the presence of this gas that so many miners who have lost their lives, have been found sitting as if in life, out of reach of explosion and above the possible level of CO_2.

"One half of 1 per cent of CO in the atmosphere is fatal to life, although it will not interfere with combustion. Many rescuers, while their lamps have continued to burn brightly, have themselves been obliged to retreat, suffering from headache and prostration, and dead men have been found with lamps burning brightly by their sides. Carbonic acid gas will not permit a lamp to continue burning, but carbonic oxide will.

"Incandescent carbon (carbon at white heat) reduces carbonic acid to carbonic oxide. The presence of coal dust has been the means of giving off large quantities of CO, and it is to the pres-

ence of this gas more than to that of carbonic acid, that the dangers of breathing after-damp exist.

"After-damp is a variable mixture of several gases. An explosion of fire-damp destroys the oxygen in the air, and carbonic acid, carbonic oxide and vapor water are formed. Nitrogen is also present. These gases mingle with each other, but are not combined by the force of chemical affinity.

"Carbonic oxide (CO) is poisonous and is fatal to life if breathed when one-half of one per cent is present in the atmosphere.

"Although mixtures containing more than 9.5 per cent of CH_4 are not likely to occur, still the properties of CO make the possibility of the product of this gas in an explosion a matter of great import. It is also produced in mine fires, by any extensive explosion, and the proportion is increased and the deadly effects intensified when coal dust takes part in the explosion.

"Exhaustive research has shown that the effect of breathing air containing a large percentage of marsh gas is to cause giddiness, which, however, rapidly disappears on a return to fresh air. This giddiness is produced by breathing air which has been deprived of part of its oxygen. Marsh gas is not poisonous to the system, nor does it deprive the blood of its oxygen, as does the deadly carbonic oxide.

"By the explosion of fire-damp, the free oxygen of the air is used up and carbonic acid gas, steam, and, under certain conditions, as when coal dust is present, carbonic oxide, are produced, which, together with the nitrogen from the air, form the dangerous after-damp. The French Fire Damp commission showed that the explosion or combustion of mixtures containing less than .5 per cent of fire-damp, carbon dioxide and steam are produced; but when the percentage of fire-damp exceeds 9.5 per cent, not only is carbon monoxide formed, but a portion of the fire-damp, together with the hydrogen, remains unburnt. The products of combustion of a 12 per cent mixture were found, after the condensation of the steam, to have the following composition. 4.8 per cent carbon dioxide, 3.9 per cent carbon monoxide, 2.5 per cent marsh gas and other hydro-carbons, 3.5 per cent hydrogen and 82.2 per cent nitrogen.

"Carbon monoxide (CO) is poisonous in very small quantities —from .2 to .4 per cent—for, as is well known, the deadly effects

of coal gas are attributable entirely to the small amount of carbonic oxide contained in it. In mining, not only is the production of CO to be feared from fires in the mine, for it will also be found among the products of any extensive mine explosion, and is measureably increased and the effects intensified when coal dust takes part in the explosion.

"CO is detected by causing headache and prostration, when breathed.

"Carbonic oxide is composed of one atom of carbon and one atom of oxygen. Its chemical formula is CO, and its molecular weight is 28 (atomic weight of C 12 and of O 16). It is found in the after-damp of an explosion. It is formed by the combustion of gunpowder and in all cases where carbon is burned without a sufficient supply of oxygen to make the combustion complete.

"The resulting after-damp of an explosive mixture containing more than 9.5 per cent of CH_4 is more dangerous than the after-damp resulting from a mixture containing less than 9.5 per cent of CH_4, because the deadly carbonic oxide (CO) is formed in addition to the usual carbonic acid gas and steam. When less than 9.5 per cent of CH_4 is present before explosion, carbonic acid gas and steam are formed, but no carbonic oxide. In support of this theory, two volumes of marsh gas (CH_4) require for complete combustion, four volumes of oxygen. Taking the average percentage of oxygen in 100 volumes of air as 20.7 volumes, then air must be mixed with CH, to burn completely, as follows: Since 2 volumes of CH require 4 volumes of O, half as much CH as O is required; therefore, 20.7 volumes of O will require

$$\frac{20.7}{2} = 10.35$$

volumes of CH_4 The total volume of air and CH_4 is, therefore, 100 volumes of air by 10.35 volumes of CH_4=110.35 volumes. The percentage of CH_4 in this mixture, is found thus: (Total volume 110.35) volume CH_4, 10.35, 100 per cent; X from which X is found to be 9.38 per cent of the total volume. And holding to the theory that CO is generated where combustion is incomplete, when this amount or less percentage of CH_4 is present before explosion, combustion is complete, and CO_2 and steam are formed, but no carbonic oxide. And to add more CH_4, as

long as the percentage does not get beyond the explosive point—which would be, according to the experiments of Maillard and Le Chatelier, made for the French Fire Damp commission—showed that a mixture of CH_4 and air, began to be explosive with 7.7 per cent of CH_4 (1 volume of CH_4 and 12 volumes of air), and the maximum explosive effect was reached with 10.8 (1 : 8.3), and the mixture ceased to be explosive with 14.5 per cent (1 : 5.9), would generate carbonic oxide.

Fairley, in Mine Ventilation Made Easy, says:

"Carbonic oxide or carbon monoxide (CO) is composed by weight of 56.69 per cent oxygen and 43.31 per cent of carbon, and its specific gravity is .975, air being 1. This gas has a far more deleterious effect on the animal system, than carbonic acid, for if atmospheric air be mixed with one per cent of it, the breathing of it is fatal, while, at the same time, a lamp will burn in it. It is found where gob fires exist and is the result of incomplete combustion. It is inflammable, and as the late Mr. Henry Johnson stated, in his evidence before the Royal Commission on Accidents in Mines in Great Britain, explosions from spontaneous combustion are due to a certain admixture of the atmosphere with carbonic oxide.

"It is a colorless and invisible gas, without taste or smell, and burns with a bright, blue flame. Gob fires, or spontaneous combustion in goaves, take place through leaving large accumulations of slack or small coal in the mine, and they are more frequent in thick than in small veins. The thicker the coal lies on the floor, and the damper it is, the quicker it fires. The primary cause of gob fires at Dudly, England, this coal is not attributed to the presence and oxidation of iron pyrites, but it is considered that the spontaneous combustion takes place through the action of oxygen upon the finely divided coal. The seam of coal in South Staffordshire, England, which contains the largest quantity of iron pyrites—namely, the "stinking" coal—is not liable to spontaneous combustion. Mr. Henry Johnson said before the Royal Commission on Accidents in Great Britain, that "the more impure the coal, the more rapid the spontaneous combustion; a hard, bright coal will produce less gob fire than soft, impure, rubbishy coal." Gob fires which are almost unknown in the deep coal, have frequently taken place, in fact, are of common occurrence, in the shallow coal of the Cannock-Chase district; and it is a noteworthy fact that more such fires occur dur-

ing a slackness of trade than at other times, more small coal being left in the gob, and the working face not advancing so rapidly then. The reason there are more fires in the shallow than in the deep mines, may be that the shallow is the more volatile coal and likewise contains the most dirt. To prevent such fires the slack should not be allowed to accumulate. Gob fires are not known in the anthracite mines of America or Great Britain."

The new International Encyclopedia says: Carbonic oxide (CO) is a gaseous compound of carbon and oxygen. It does not occur naturally. * * * During the combustion of lower layers of fuel, the oxygen of the air unites with the carbon of the fuel to form carbonic acid CO_2; and this gas, rising through red hot coal, has part of its oxygen abstracted by the latter, and as a result, carbonic oxide is produced, which, taking fire on top of the coals, burns, abstracting more oxygen from the air and reforming carbonic acid, CO_2. Carbonic oxide may be prepared by heating either potassium ferrocyanide or oxalic acid with strong sulphuric acid. It is a colorless gas somewhat lighter than air, in which it burns with a characteristic blue flame. It is exceedingly poisonous, forming a chemical compound with the haeemoglobin of the blood, and thus preeventing the latter from carrying the oxygen that is necessary for the supporting of life. The symptoms of carbonic oxide poisoning are headache, dizziness and nausea, which, if the inhalation of the gas is continued, terminate in death. * * * The presence of carbonic oxide in the air may be best detected by means of a solution of palladium chloride; if a cloth moistened with a strong solution of this salt is exposed to air containing traces of this poisonous gas, a distinct brown coloration is produced. Among the compounds of carbon, carbonic oxide is the only one in which that element occurs in the divalent state; in all other compounds carbon is quadrivalent.

Elroy M. Avery, Ph. D., LL. D., in his chemical work, says:

"Carbon monoxide (carbon protoxide, carbonic oxide, carbonous oxide, carbonyl, CO) yields, when burned, the characteristic blue flame often seen playing over a freshly-fed coke fire or anthracite fire. It may be prepared by passing steam over highly heated carbon.

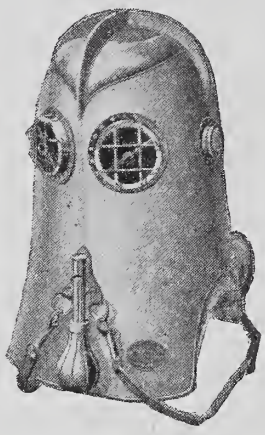
"Carbon monoxide is a colorless, odorless, poisonous gas. It is a little lighter than air, having a density of 14. It is scarcely soluble in water, but is wholly absorbed by an acid or an ammoniacal solution of cuprous chloride (CuCl). It is liquifiable only with extreme difficulty. Like hydrogen, it does not support combustion, but is combustible. It burns with a pale blue flame and yields carbon dioxide (CO_2) as the sole product of its combustion. It is an active poison and doubly dangerous on account of its lack of odor. One per cent of it in the air is fatal to life, which it destroys, not merely by excluding oxygen (suffocation), as hydrogen, nitrogen, etc., but by direct action as a true poison. It acts as a poison by uniting chemically with the red corpuscles of the blood, thus destroying their oxygen-carrying capacity. For this reason, the best antidote is the free inhalation of pure oxygen. * * * Carbon monoxide is rightly chargeable with many of the ill effects usually attributed to the less danerous dioxide.

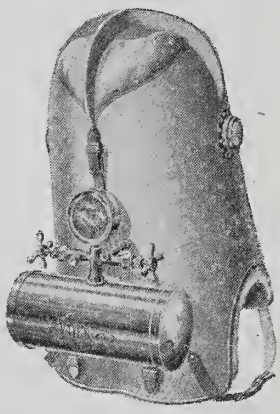
Carbon monoxide is readily oxidized to the dioxide, and the dioxide is easily reduced to the monoxide. Thus, when air enters at the bottom of an anthracite fire, the oxygen unites with the carbon to form carbon dioxide. As this gas rises through the glowing coals above, it is reduced. ($CO+C=CO.$) When this heated monoxide comes into contact with the air above the coals, it burns with its characteristic blue flame. ($CO+O=CO_2.$) If the oxygen necessary for this second combustion is not present, the dangerous monoxide will escape."

THE VAJEN HEAD PROTECTORS.

Two Vajen head protectors have been provided by the department for inspection and rescue work. The hoods are made of fireproof glove horse hide, stretched over and glued to a stiffening layer of split leather. These layers are glued and sewed together by hand, making the hood perfectly airtight, and practically indestructible by either wear and tear or by fire. The reservoirs are made of seamless brass tubing, tested for 150 pounds, and more, pressure, and are kept filled ready for emergencies. A gauge is set on the reservoir to indicate the pressure of contained air. The flow of air is regulated by a gold-plated needle valve, and can also be regulated by a wheel-turn valve on

the reservoir. Sufficient air for two or three hours' work can be carried in the reservoir. There is a hand whistle signal in front which can be operater by the wearer. The protector is simple to operate and there are no complicated attachments. A good sized bicycle pump is used to refill the reservoir with fresh





air. The inside of the protector which fits about the neck of the wearer, is faced with sheep's wool and is drawn snugly around the neck with elastic. No gases can possibly get inside the hood or helmet. Two eye-holes covered with isinglass, firmly bushed with felting, insuring its being perfectly airtight. While the hood is large and roomy, it is not cumbersome to the wearer, as the weight is evenly distributed over both shoulders, the hood being strapped from the back of the helmet underneath the arms and clasped in front on the breast of the wearer. It can be easily put on and adjusted and can be quickly removed. We think that any mine that gives off explosive or noxious gases, or is liable to spontaneous combustion, should be provided with at least two helmets. We are of the opinion that, in most cases, one would be useless for rescue work, but with two men accustomed to wearing the hoods, almost any atmosphere can be entered with perfect safety and rescue work made speedy and effective.

Mining Laws.

Laws of Montana Relating to Coal and Coal Mining.

SENATE BILL NO. 106.

Session Laws of 1901.

An Act Entitled An Act creating the Office of Inspector of Coal Mines, defining his duties, and providing his salary and providing penalties thereof.

Be it Enacted by the Legislative Assembly of the State of Montana.

Section 1. The Governor, by and with the advice and consent of the Senate, shall appoint one coal mine inspector who shall hold office for the term of four years from the date of his appointment unless otherwise removed by the Governor.

Sec. 2. No person shall be eligible to the office of coal mine inspector until he shall have attained the age of 30 years, and been actually employed at coal mining ten years prior to his appointment, and shall possess a competent knowledge of all the different systems of coal mining and working and properly ventilating coal mines, and the nature and constituent parts of noxious gases of coal mines, and of the various ways of expelling the same from said mines. Said inspector shall be a graduate of some recognized school of mines and mining engineering, and hold a diploma from same, which shall be deposited with the Governor before appointed; and further it shall be the duty of the said inspector, when not engaged in examining coal mines, to inspect quartz mines if called by the Governor to do so.

Sec. 3. Said coal mine inspector shall before entering upon and discharging the duties of his office, take an oath to faithfully discharging the same in an impartial manner; and for the faithful performance thereof, he shall receive a salary of two thousand dollars per annum, and all other and necessary traveling expenses.

Sec. 4. It shall be the duty of the said coal mine inspector to carefully examine all coal mines that may be in operation in this state at least once every two months and oftener if necessary, to see that every precaution is taken to insure safety to all workmen that may be engaged in said coal mines, and to see that provisions of Sections 3350, 3351, 3352, 3353, 3354, 3355, 3356, 3357,

3358, 3359, 3360, 3361, 3362, 3363, 3364 and 3365, Chapter 20, Article 1, Part 3, Title 7, of the Political Code of Montana pertaining to the regulation of coal mines are strictly observed; and all other legislation that may be enacted governing coal mines, and it shall further be the duty of the said coal mine inspector after being notified by a justice of the peace, or coroner, in the districts wherein accidents may occur to immediately investigate the same.

Sec. 5. The said coal mine inspector while in office shall not act as agent for any corporation, superintendent or manager of any mine, and shall in no manner whatever be under the employ of mining companies, and it shall be the duty of the said coal mine inspector on or before the first day of January in every year to make a report to the Governor, of his proceedings as such coal mine inspector, and the conditions of each and every coal mine in the State, stating therein all accidents that may have happened in or about said mine, and to set forth in said report all such information that may be proper and beneficial and also to make such suggestion as he may deem important as to any further legislation on the subject of coal mining.

Sec. 6. It is the duty of the inspector of coal mines to visit, enter and examine any coal mine in the State for the purpose of ascertaining the conditions of the same in regard to its safety, ventilation and means of egress, and for this purpose he must have access at any and all times to any mine in the State for the purpose of inspection, but the workings of such mine must not be obstructed or impeded during such examination; the inspection must not be at the expense of the owner, lessor, lessee, or agent of the mine being examined, but they must render such assistance as may be necessary to enable the inspector to make the examination.

Sec. 7. This Act shall be in force and effect from and after its passage and approval.

Approved March 18th, 1901.

REGULATION OF COAL MINES.

Political Code.

Sec. 3350. The owner or operator of any coal mine in the State must make, or cause to be made, an accurate map or plan of the mine, which must exhibit the openings or excavations, the shafts, slopes, or tunnels, the entries, rooms, or other workings, must show the direction of the air currents therein, accurately delineate the surface section lines of the coal lands controlled by the owner of said mines and show the exact relation to and proximity of the workings of said mines to said surface lines; said map, or plan, must also show the exact date of each survey made, and indicate the boundary line of the most advanced face of the workings at such date; and in case more than one seam of coal is opened or worked, a separate map or plan as aforesaid, must, if desired by the inspector, be made of the working in each seam. The map, or plan, or a true copy thereof, with the record of all surveys of said boundary lines and underground workings, must be delivered to the State inspector of mines, and the original or a true copy of the same must be retained for reference and inspection at the office of the coal mine. The maps and plans so delivered to the Inspector of Mines are the property of the State and must be transferred to his successor in office. Maps of mines filed with the Inspector must be open to the examination of the public in the presence of the inspector, but in no case must any copy of the same be made without the consent of the owner, operator, or his agent.

Sec. 3351. After the maps and plans herein provided are com-

pleted, thereafter in July of each year, the owner or operator of every coal mine must cause surveys to be made of all alterations and extensions of the workings made during the year preceding, and must have the records and results of the survey duly entered upon the maps of the inspector, and upon that kept at the mine. The said extensions must be placed upon the Inspector's map and the map returned to the inspector within thirty days from the completion of the survey. When any coal mine is worked out, and is about to be abandoned the owner or operator must have the maps or plans thereof extended to include all the excavations made showing the most advanced workings of every part of the mine and the relation of such boundaries to marked boundaries on the surface.

Sec. 3352. Whenever the owner or operator of any coal mine neglects or refuses to furnish the inspector the map or plan of such coal mine, or the extensions thereto, as provided for in this Chapter, the inspector is authorized to make, or cause to be made, an accurate map or plan of such coal mine, at the expense of the owner, and the cost may be recovered from the owner or operator, in the same manner as other debts, in the name of the State.

Sec. 3353. For all coal mines in this state, when more than six men are employed, other than the owners or operators of such mine, whether worked by shaft, slope or drift, there must be provided and maintained in addition to the hoisting shaft or opening, a separate escapement shaft or opening to the surface, or an underground opening or communication between every such mine and some other contiguous mine, as may be approved by the Mine Inspector, as coming within the requirements of this Chapter, which openings constitute two separate and available means of ingress and egress to all persons employed in the mine, and all passage-ways communicating with the escapement shafts must be at least five feet wide and five feet high.

Sec. 3354. Every escapement shaft must be separated from the main shaft by such extent of natural strata as shall secure safety to the men employed in such mines, and provided with either stairways, or cages and hoisting apparatus, as in the judgment of the inspector of mines may be sufficient to insure the safe and speedy removal of all persons within the mine in case of danger. No obstructions of any kind must be permitted in any escapement shaft that would in any way impede travel

through the same. The time allowed for completing such escapement shaft or making such communication with an adjacent mine, as is required by the terms of this Chapter, is for all mines already opened or in process of development on the sixth day of March, 1891, one year for sinking any shaft two hundred feet or less in depth, and one additional year or pro-rata portion thereof for every additional two hundred feet, or fraction thereof; but for mines which are opened thereafter the time allowed shall be two years for all shafts more than two hundred feet in depth, and one year for all shafts two hundred feet or less in depth, and the time must be reckoned in all cases from the date on which coal is first hoisted from the original shaft for sale or use, and it is the duty of the inspector of mines to see that all escapement shafts are begun in time to secure the completion within the time herein specified.

Sec. 3355. The owner or operator of every coal mine, whether operated by shaft, slope or drift, must provide and maintain for every such mine a good and sufficient amount of ventilation for man and animals employed therein; the amount of air in circulation to be in no case less than one hundred cubic feet for each man, and six hundred cubic feet for each animal per minute, measured at the foot of the down cast, and the same to be increased at the discretion of the inspector according to the character and extent of the workings, or to the amount of powder used in blasting, and the volume of air must be forced and circulated to the face of every working place throughout the mine, so that the mine is free from standing powder smoke and gases of every kind. All doors set on main entries for the purpose of conducting ventilation must be so constructed and hung as to close of themselves when opened, and must be made sufficiently tight to effectually obstruct the air currents.

Sec. 3356. In all the larger mines, a suitable person as doorkeeper must be kept in attendance upon such doors, to see that they are kept securely closed and the air currents properly controlled. Whenever the inspector finds men working without sufficient air or under any unsafe conditions, he must first give the owner or operator a reasonable notice to rectify the same; upon the neglect or refusal of the owner or operator of the mine to put the same in a safe condition, as required by the inspector, the inspector must proceed by an action to enjoin the further workings of the mine until the law is complied with. All ac-

tions for an injunction must be brought by the county attorney, or by the Attorney General in the name of the State.

Sec. 3357. All mines in which explosive gases are known to exist must be examined every morning by a duly authorized agent of the owner or operator, to determine whether there are any dangerous accumulations of gases or lack of ventilation or obstruction to roadways or any other dangerous conditions and no person must be allowed to enter the mine until the agent has reported all the conditions safe for beginning work; the agent must make a daily record of the conditions of the mine in a book kept for that purpose, which shall be open at all times to the examination of the inspector. The current of air in mines must be split, so as to give a separate current to at least every one hundred men at work, and the inspector has the discretion to order a separate current for a smaller number of men if special conditions render it necessary. In case the entries or roadways of any mine are so dry as to become filled with dust, the owner or operator of the mines is required to have such roadways regularly and thoroughly sprinkled and it is the duty of the inspector to see that in all mines every practicable precaution is taken against accident from the careless handling of powder within the mine.

Sec. 3358. In no case must more powder be stored in the mine at any one time than in the discretion of the inspector is necessary for each day's use. It is unlawful for coal miners in any mine to charge a blasting hole with the loose powder or otherwise than with the properly constructed cartridge; and in dry and dusty mines it is unlawful to load cartridges in the mines except with powder cans construscted for that purpose. It is unlawful for the owner or operator of any mine to permit miners to work in said mines with tools prohibited by law. It is unlawful for any owner or operator of any mine where dangerous or explosive gases are known to exist to employ any person as foreman or boss of said mine, who does not possess a thorough, practical knowledge of the nature and danger of inflammable or explosive gases and understand the means and appliances for controlling them.

Sec. 3359. It is unlawful for any person to act as foreman or mine boss of any mine in which inflammable gases are known to exist who does not possess a certificate from the state mine inspector certifying to his competency for managing the under-

ground workings of mines, together with a thorough knowledge of all gases met with in coal mines and of the most approved means of appliances for controlling them, and the inspector of mines is authorized to examine all foremen or mine bosses upon their competency under the provisions of this Chapter and issue his certificate to those whom he considers qualified to act as such foreman or boss within the meaning of this law. It is unlawful for any owner or operator of a coal mine to employ persons underground whose duties may involve contact with inflammable gases or the handling of explosives, who have not had experience in such duties, unless all such employes are placed under the immediate charge and instruction of such number of competent men as to secure the safety of other persons employed in the same mine.

Sec. 3360. The ventilation required by this Chapter may be produced by any suitable appliances, but in case a furnace is used for ventilating purposes it must be built in such a manner as to prevent the communication of fire to any part of the works by lining the upcast with incombustible material for a sufficient distance up from the furnace. It is unlawful to use a furnace for ventilating purposes or for any other purpose that emits smoke into any compartment constructed in or adjoining any hoisting shaft or slope where the hoisting shaft or slope is the only means provided for the ingress or egress of persons employed in said coal mines. It is unlawful where there is but one means of ingress and egress provided at a coal shaft or slope to construct and use a ventilating furnace that emits smoke into a shaft as an upcast where the shaft or slope used as a means of ingress and egress by persons employed in said coal mines is the only means provided for furnishing air for persons employed therein.

Sec. 3361. The owner or operator of a coal mine operated by shaft must provide safe means of hoisting and lowering persons in a cage covered with boiler iron, so as to keep safe as far as possible persons descending into and ascending out of said shaft, and said cage must be furnished with guides to conduct iron slides through such shaft, with a sufficient brake on every drum to prevent accident in case of the giving out or breaking of the machinery; and such cages must be furnished with safety catches intended and provided as far as possible to prevent accident in case of cable breaking or the loosening or disconnecting

of machinery. The owner or operator of every coal mine operated by shaft and steam power must place competent persons at the top and bottom of such shaft for the purpose of attending to signals while the men are being lowered or hoisted out of the mine; they must be at their post of duty at least thirty minutes before the hoisting of coal is commenced in the morning and remain at least thirty minutes after the hoisting of coal has ceased at night. It is also their duty to see that the men do not carry any tools, timber, or material with them on the cage, and that only the proper number of men are allowed upon the cage at one time. A sufficient light must be furnished at the top and bottom of the shaft to insure as far as possible the safety of persons getting on or off the cage.

Sec. 3362. A suitable code of signals between the bottom man and the top man and engineer must be established to provide and insure the safety of persons being lowered into and hoisted out of any shaft; said code of signals so established must be conspicuously posted at the top and bottom of the shaft and in the engine room. No person must ride upon a loaded cage or car used for hoisting purposes in any shaft or slope, and in no case must more than twelve persons ride in any cage or car at any one time nor must any coal be hoisted out of any coal mine, except in cases where coal is being hoisted out of a slope which is not less than ten feet wide and only one track operated therein, while persons are descending into such mine. The number of persons permitted to ascend out of or descend into any coal mine at one time must be determined by the inspector, and they must not be lowered or hoisted more rapidly than five hundred feet per minute.

The top of each and every shaft and the entrance to each and every intermediate working vein must be securely fenced by gates, properly protecting such shaft and the entrance thereto, and the entrance to every abandoned slope, air or other shaft must be securely fenced off.

Sec. 3363. All underground, self-acting or engine planes, with single track, on which coal cars are drawn and persons travel, must be provided with proper means of signaling between the stopping places and ends of said planes, and sufficient places of refuge at the side of such planes must be provided at intervals of not more than ten yards and all their other single planes or gangways, twenty yards, and they must not be less than six

feet wide and whitewashed or otherwise distinguished from the surrounding walk. The bottom of every shaft must be supplied with a traveling way, to enable men to pass from one side of the shaft to the other without passing under or over the cage. All sumps must be securely planked over, so as to prevent accident.

Sec. 3364. Any person neglecting or refusing to perform the duties required by any of the provisions of this Chapter is punishable as provided in Section 718, of the Penal Code.

Sec. 3365. The inspector of mines is authorized to provide, at the expense of the State, all necessary air meters, barometers, or other instruments for the use of himself and deputy in making all investigations and inspections, as required by this Chapter.

CHECK WEIGHMAN.

HOUSE BILL NO. 25.

Session Laws of 1901.

An Act entitled, "An Act providing for the employment of a Check Weighman at Coal Mines, prescribing his duties, and providing penalty for violation thereof."

Be it Enacted by the Legislative Assembly of the State of Montana:

Section 1. The weighman employed at any mine shall subscribe to an oath or affirmation before a justice of the peace, or other officer authorized to administer oaths, to do justice between employer and employee, and to truly and correctly weigh the output of coal from the mines as herein provided. The miners employed by or engaged in working for any mine owner, operator or lessee of any mine in this state shall have the privilege, if they desire, of employing at their own expense a check weighman, who shall have like equal rights, power and privileges in the weighing of coal as the regular weighman, and be subject to the same oath and penalties as the regular weighman. Said oath or affirmation shall be kept conspicuously posted in the weight office, and any weigher of coal or person so employed, who shall knowingly violate any of the provisions of this article, or any owner, operator or agent of any coal mine in this state who shall forbid or hinder miners employing or using a check weighman as herein provided, or who shall prevent or wilfully

obstruct any such check weighman in the discharge of his duty, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than One Hundred Dollars or more than Five Hundred Dollars for each offense, or by imprisonment in the county jail for a period of not less than thirty days nor more than ninety days, or by both such fine and imprisonment, proceedings to be instituted in any court having competent jurisdiction. Whenever the inspector of mines, or deputy inspector of mines shall be satisfied that the provisions of this section have been wilfully violated, it shall be his duty to forthwith inform the prosecuting attorney of any such violation, together with all the facts within his knowledge and the prosecuting attorney shall thereupon investigate the charges so preferred, and if he be satisfied that the provisions of this section have been violated, it shall be his duty to prosecute the person or persons guilty thereof.

Sec. 2. Any person or persons having or using any scale or scales for the purpose of weighing the output of coal at mines, so arranged or constructed that fraudulent weighing may be done thereby, or who shall knowingly resort to or employ any means whatsover, by reason of which such coal is not correctly weighed and reported in accordance with the provisions of this Article, shall be deemed guilty of a misdemeanor and shall, upon conviction, for each such offense, be punished by a fine of not less than Two Hundred Dollars nor more than Five Hundred Dollars, or by imprisonment in the county jail for a period not to exceed sixty days, or by both such fine and imprisonment, proceedings to be instituted in any court of competent jurisdiction.

WEIGHT OF COAL.

HOUSE BILL NO. 46.

Session Laws of 1901.

An Act entitled "An Act amending Section 3134, Chapter 6, Part 3, Title 7, of the Political Code of the State of Montana, Relating to Standard Weights and Measures."

Be it Enacted by the Legislative Assembly of the State of Montana:

Section 1. That Section 3134, Chapter 6, Part 3, Title 7, of the Political Code of the State of Montana relating to standard

weights and measures be, and the same is hereby amended to read as follows:

Sec. 3134. The ton consists of twenty hundred pounds, but a ton of mineral coal is expressed by the conventional quantity of twenty-six and one-third bushels of seventy-six pounds each. A bushel of each of the articles hereinafter named consists of the number of pounds affixed to each, to-wit:

	Pounds.
Apples and pears	45
Beans	60
Bran	20
Carrots	50
Barley	48
Beets	50
Buckwheat	52
Coal, Mineral	76
Corn, in the ear	70
Corn meal	50
Lime, unslacked	80
Oats	32
Parsnips	50
Peas	60
Salt	50
Corn, shelled	56
Hay, per ton	2000
Malt	30
Onions	57
Potatoes	60
Rye	56
Seeds—	Pounds.
Blue Grass	14
Timothy	45
Hemp	44
Turnips	50
Clover	60
Hungarian Grass	50
Flax	56
Wheat	60

Any person, persons, companies or corporations who shall violate the provisions of this section by demanding, exacting or taking more than the prescribed number of pounds per bushel or per ton as fixed by the provisions of this Section, shall be guilty of a misdemeanor and upon conviction thereof, shall be punished by a fine of not less than One Hundred Dollars nor more than Five Hundred Dollars, or by imprisonment in the

county jail not less than three nor more than six months or by both such fine and imprisonment, in the discretion of the court.

Sec. 2. This Act shall take effect from and after its passage and approval by the Governor.

Aproved February 18th, 1901.

CHAPTER LIII.

Session Laws of 1903.

An Act entitled "An Act for the Protection of the Health of Engineers and for the Safety of Men Employed Underground, by Regulating the Hours of Labor of Hoisting Engineers and Fixing the Penalties for Violation Thereof.

Be it Enacted by the Legislative Assembly of the State of Montana:

Section 1. That on and after the first day of May, A. D. 1903, it shall be unlawful for any person or persons, company or corporation, to operate or handle, or to induce, persuade or prevail upon any person or persons to operate or handle, for more than eight hours in twenty-four hours of each day, any hoisting engine at or in any mine. This Act shall apply only to such plants as are in continuous operation or are operated sixteen or more hours in twenty-four hours of each day, or at or in any mine where said hoisting engine develops fifteen or more horsepower, or at or in any mine wherein there are fifteen or more men employed underground in twenty-four hours of each day. Provided, however, that the provisions of this Act shall not apply to any person or persons operating any hoisting engine more than eight hours in each twenty-four hours for the purpose of relieving another employee in case of sickness or other unforeseen cause or causes.

Sec. 2. Any person or persons, company or corporation, who shall violate any of the provisions of this Act shall, upon conviction, be punished by a fine of not less than ten ($10.00) dollars, nor more than one hundred ($100.00) dollars; and each and every day that such person or persons, company or corporation may continue to violate any of the provisions of this Act, shall be considered a separate and distinct offense and shall be punishable as such.

Sec. 3. That all Acts and parts of Acts in conflict with this Act are hereby repealed.

CHAPTER LXXXIII.

Session Laws of 1903.

An act entitled an Act to determine the liability of employers in this State for damages to employees.

Be it Enacted by the Legislative Assembly of the State of Montana:

Section 1. Every railway corporation including electric railway corporations, doing business in this State shall be liable for all damages sustained by an employe thereof, within this State, without contributing negligence on his part, when such damages are caused by the negligence of any train dispatcher, telegraph operator, superintendent, master mechanic, yardmaster, conductor, engineer, motorman, or any other employe who has superintendence of any stationary or hand signal.

Sec. 2. That every company, corporation, or individual operating any mine, smelter or mill for the refining of ores shall be liable for all damages sustained by an employe thereof within this State, without contributing negligence on his part when such damage is caused by the negligence of any superintendent, foreman, shift-boss, hoisting or other engineer, or crane-man.

Seec. 3. All Acts and parts of Acts in conflict herewith are hereby repealed.

Sec. 4. This Act shall take effect and be in force from and after its passage and approval by the Governor.

HOUSE BILL NO. 1.

Session Laws of 1901.

An Act for the Protection of the Health of Men Employed in Underground Mines and in Smelters, Stamp Mills, Sampling Works, Concentrators, or any works where Ores are Mined or Reduced, by Regulating their hours of employment and providing penalties for the violation thereof.

Be it Enacted by the Legislative Assembly of the State of Montana.

Section 1. The period of employment of working men in all underground mines or workings, shall be eight (8) hours per day except in cases of emergency where life or property is in imminent danger.

Sec. 2. The period of employment of working men in smelters, stamp mills, sampling works, concentrators, and all other institutions for the reduction of ores, and refining of ores or metals, shall be eight (8) hours per day, except in cases of emergency where life or property is in imminent danger.

Sec. 3. Any person or persons, body corporate, agent, manager or employer who shall violate any of the provisions of Section one (1) or Two (2) of this Act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall, for each offense, be subject to a fine of not less than One Hundred Dollars or more than Five Hundred Dollars, or by imprisonment in the county jail for a period of not less than one (1) month, or more than six (6) months or by both such fine and imprisonment.

Sec. 4. All Acts or parts of Acts in conflict with this Act are hereby repealed.

Sec. 5. This Act shall not be in full force and effect until ninety days after its passage and approval by the Governor.

Approved February 2nd, 1901.

SENATE BILL NO. 56.

An Act to prevent all persons Owning or Operating a Coal Mine on the Bank of a Stream containing Fish or Water which is used for Domestic Purposes or for Irrigation, from Depositing Coal Slack or Screenings from such mine in such stream, and for Fixing the Penalty for Failure to Comply with the Law.

Be it Enacted by the Legislative Assembly of the State of Montana.

All persons owning or having in operation and all persons who may hereafter own or put in operation in the State of Montana, either in person or by agent, any coal mine on any stream containing fish or water which is used for domestic purposes, or for irrigation, are hereby prohibited from dumping, or causing to be dumped or deposited, any coal slack or screenings emanating from such coal mining operation into the waters of such stream. Provided, that this Act shall not be construed to prohibit persons, companies or corporations from dumping into or returning to said stream the water and refuse from coal washing or cleaning machinery or plants that may be situated on or contiguous to any such stream.

All persons owning or operating or who may hereafter own or operate any coal mine on any stream containing fish or water which is used for domestic purposes, or for irrigation, who shall drop, dump, cart or deposit, or cause or suffer to be deposited in such stream any such coal slack or coal screenings emanating from such coal mining operation, shall be deemed guilty of a misdemeanor, and upon conviction thereof before any court of any competent jurisdiction, shall be fined in any sum not less than two hundred dollars ($200.00) nor more than Five Hundred ($500.00) dollars for each and every offense.

Sec. 2. This Act shall be in force and effect on and after November 1st, 1901.

Approved March 9th, 1901.

IN CASE OF ACCIDENTS.

The law governing notification, etc., of the inspector in case of mine accidents, is as follows:

Sec. 586, Political Code: "Whenever a serious or fatal accident occurs in any mine it is the duty of the person in charge thereof to immediately notify the inspector of mines or the deputy inspector, and upon receiving such notice the inspector in person or the deputy inspector must at once repair to the place of accident, and investigate fully the cause of such accident and whenever possible to do so, the inspector or deputy inspector shall be present at the coroner's inquest held over the remains of the person or persons killed by such accident, and testify as to the cause thereof, and state whether, in his opinion, the accident was due to the negligence or mismanagement of the owner or person in charge. If the inspector or deputy inspector can not be immediately present in case of a fatal or serious accident occurring, it is the duty of the owner or person in charge of the mine to have written statements made by those witnessing the same, and duly sworn to. In case no person was present at the time of the accident, then the verified statement of those first present after the accident must be taken, and such statement must be given to the inspector or the deputy inspector. If, after making such investigation, the inspector deems the facts warrant it, he may prosecute criminally the owner, lessor, lessee, or agent of the mine in which such accident occurred."

Coal-Land Law and Regulations Thereunder.

Department of the Interior,
General Land Office,
Washington D. C., July 31, 1882.

The following sections of the Revised Statutes provide for the sale of coal lands of the United States:

TITLE XXXII, CHAPTER 6.

MINERAL LANDS AND MINING RESOURCES.

Sec. 2347. Every person above the age of twenty-one years, who is a citizen of the United States, or who has declared his intention to became such, or any association of persons severally qualified as above, shall, upon application to the register of the proper land office, have the right to enter, by legal subdivisions, any quantity of vacant coal lands of the United States not otherwise appropriated or reserved by competent authority, not exceeding one hundred and sixty acres to such individual person, or three hundred and twenty acres to such association, upon payment to the receiver of not less than ten dollars per acre for such lands, where the same shall be situated not more than fifteen miles from any completed railroad, and not less than twenty dollars per acre for such lands as shall be within fifteen miles of such road.

Sec. 2348. Any person or association of persons severally qualified, as above provided, who have opened and improved, or shall hereafter open and improve, any coal mine or mines upon the public lands, and shall be in actual possession of the same, shall be entitled to a preference-right of entry, under the preceding section, of the mines so opened and improved: Provided, That when any association of not less than four persons, severally qualified as above provided, shall have expended not less than five thousand dollars in working and improving any such mine or mines, such association may enter not exceeding six hundred and forty acres, including such mining improvements.

Sec. 2349. All claims under the preceding section must be presented to the register of the proper land district within sixty

days after the date of actual possession and the commencement of improvements on the land, by the filing of a declaratory statement therefor; but when the township plat is not on file at the date of such improvement, filing must be made within sixty days from the receipt of such plat at the district office; and where the improvements shall have been made prior to the expiration of three months from the third day of March, eighteen hundred and seventy-three, sixty days from the expiration of such three months shall be allowed for the filing of a declaratory statement, and no sale under the provisions of this section shall be allowed until the expiration of six months from the third day of March, eighteen hundred and seventy-three.

Sec. 2350. The three preceding sections shall be held to authorize only one entry by the same person or association of persons; and no association of persons any member of which shall have taken the benefit of such sections, either as an individual or as a member of any other association, shall enter or hold any other lands under their provisions; and all persons claiming under section twenty-three hundred and forty-eight shall be required to prove their respective rights and pay for the lands filed upon within one year from the time prescribed for filing their respective claims; and upon failure to file the proper notice, or to pay for the land within the required period, the same shall be subject to entry by any other qualified applicant.

Sec. 2351. In case of conflicting claims when coal lands where the improvements shall be commenced, after the third day of March, eighteen hundred and seventy-three, priority of possession and improvement, followed by proper filing and continued good faith, shall determine the preference-right to purchase. And also where improvements have already been made prior to the third day of March, eighteen hundred and seventy-three, division of the land claimed may be made by legal subdivisions, to include, as near as may be, the valuable improvements of the respective parties. The Commissioner of the General Land Office is authorized to issue all needful rules and regulations for carrying into effect the provisions of this and the four preceding sections.

Sec. 2352. Nothing in the five preceding sections shall be construed to destroy or impair any rights which may have attached prior to the third day of March, eighteen hundred and seventy-

three, or to authorize the sale of lands valuable for mines of gold, silver or copper.

RULES AND REGULATIONS.

Under the authority conferred by said section 2351 the following rules and regulations are issued for carrying into effect the provisions of said law:

1. Sale of coal lands is provided for—

By ordinary private entry under section 2347.

By granting a preference right of purchase, based on priority of possession and improvement, under section 2348.

2. The land entered under either section must be by legal subdivisions, as made by the regular United States survey. Entry is confined to surveyed lands; to such as are vacant, not otherwise appropriated, reserved by competent authority, or containing valuable minerals other than coal.

3. Individuals and associations may purchase. If an individual, he must be twenty-one years of age and a citizen of the United States, or have declared his intention to become such citizen.

4. If an association of persons, each person must be qualified as above.

5. A person is not disqualified by the ownership of any quantity of other land, nor by having removed from his own land in the same State or Territory.

6. Any individual may enter by legal subdivisions as aforesaid any area not exceeding one hundred and sixty acres.

7. Any association may enter not to exceed three hundred and twenty acres.

8. Any association of not less than four persons duly qualified, who shall have expended not less than $5,000 in working and improving any coal mine or mines, may enter under section 2348 not exceeding six hundred and forty acres, including such mining improvements.

9. One person can have the benefit of one entry or filing only. He is disqualified by having made such entry or filing alone or as a member of an association. No entry can be allowed an association which has in it a single person thus disqualified, as the law prohibits the entry or holding of more than one claim either by an individual or an association.

10. Lands that are sufficiently valuable for gold, silver, or copper to prevent their entry as agricultural lands can not be entered as coal lands; and you will not allow any entry to be made under the above named provisions of law of lands valuable for their deposits of said minerals.

11. The present rule relative to "hearings to establish the character of lands," contained in General Land Office regulations of October 31, 1881, (Revision approved June 24, 1899) issued under the mining laws, will, as far as applicable, govern your action in determining the character of lands sought to be entered as coal lands.

12. The price per acre is $10 where the land is situated more than fifteen miles from any completed railroad, and $20 per acre where the land is within fifteen miles of such road. The price of the land, however, must be determined by its distance from a completed railroad at the date of payment and entry irrespective of the preference-right of entry.

13. When application is made to purchase coal land at the rate of $10 per acre you will in all cases require satisfactory proof that the land applied for is, at date of entry, situated more than fifteen miles from any completed railroad. This proof may consist of the affidavit of the applicant, or that of his duly authorized agent, corroborated by the affidavit of some disinterested credible party showing personal knowledge of the facts.

14. Where the land lies partly within fifteen miles of such road and in part outside such limit, the maximum price must be paid for all legal subdivisions the greater part of which lie within fifteen miles of such road.

15. The term "completed railroad" is held to mean one which is actually constructed on the face of the earth; and lands within fifteen miles of any point of a railroad so constructed will be held and disposed of at $20 per acre.

16. Any duly qualified person or association must be preferred as purchasers of those public lands on which they have opened and improved, or shall open and improve, any coal mine or mines, and which they shall have in actual possession.

17. Possession by agent is recognized as the possession of the principal. The clearest proof on the point of agency must, however, be required in every case, and a clearly defined possession must be established.

18. The opening and improving of a coal mine, in order to

confer a preference-right of purchase, must not be considered as a mere matter of form; the labor expended and improvements made must be such as to clearly indicate the good faith of the claimant.

19. These lands are intended to be sold, where there are adverse claimants therefor, to the party who, by substantial improvements, actual possession, and a reasonable industry, shows an intention to continue his development of the mines in preference to those who would purchase for speculative purposes only. With this view, you will require such proof of compliance with the law, when lands are applied for under section 2348 by adverse claimants as the circumstances of each case may justify.

20. In conflicts where improvements have been or shall hereafter be commenced, priority of possession and improvement shall govern the award when the law has been fully complied with by each party. A mere possession, however, without satisfactory improvements, will not secure the tract to the first occupant when a subsequent claimant shows his full compliance with the law.

21. After an entry has been allowed to one party, you will make no investigation concerning it at the instance of any person except on instructions from this office. You will, however, receive all affidavits concerning such case and forward the same to this office, accompanied by a statement of the facts as shown by your records.

MANNER OF OBTAINING TITLE.

23. When title is sought by private entry the party will himself make oath to the following application, which must be presented to the register:

I, ——— ———, hereby apply, under the provisions of the Revised Statutes of the United States relating to the sale of coal lands of the United States, to purchase the —— quarter of section ——, in township ——, of range ——, in the district of lands subject to sale at the land office at ———, and containing ———acres; and I solemnly swear that no portion of said tract is in the possession of any other party; that I am twenty-one years of age, a citizen of the United States (or have declared my intention to become a citizen of the United States), and have never held nor purchased lands under said act, either as an in-

dividual or as a member of an association; and I do further swear that I am well acquainted with the character of said described land, and with each and every legal subdivision thereof, having frequently passed over the same; that my knowledge of said land is such as to enable me to testify understandingly with regard thereto; that said land contains large deposits of coal and is chiefly valuable therefor; that there is not to my knowledge within the limits thereof any vein or lode of quartz or other rock in place bearing gold, silver or copper, and that there is not within the limits of said land, to my knowledge, any valuable deposit of gold, silver, or copper. So help me God.

——— ———.

24. Thereupon the register, if the tract is vacant, will so certify to the receiver, stating the price, and the applicant or his duly authorized agent must then pay the amount of purchase money.

25. The receiver will then issue to the purchaser a duplicate receipt, and at the close of the month the register and receiver will make returns of the sale to the General Land Office, from whence, when the proceedings are found regular, a patent or complete title will be issued; and on surrender of the duplicate receipt such patent will be delivered, at the option of the patentee either by the Commissioner at Washington or by the register at the district land office.

26. This disposition at private entry will be subject to any valid prior adverse right which may have attached to the same land and which is protected by section 2348.

27. Second. When the application to purchase is based on a priority of possession, etc., as provided for in section 2348, the claimant must, when the township plat is on file in your office, file his declaratory statement for the tract claimed sixty days from and after the first day of his actual possession and improvement. Sixty days, exclusive of the first day of possession, must be allowed.

28. The declaratory statement must be substantially as follows, to-wit.

I, ——— ———, do solemnly swear that I am ——— years of age, and a citizen of the United States (or have declared my intention to become a citizen of the United States), that I never have, either as an individual or as a member of an association, held or purchased any coal lands under the provisions of the

Revised Statutes of the United States relating to the sale of coal lands of the United States, and I do hereby declare my intention to purchase, under the provisions aforesaid, the ——— quarter of section ——, in township ——, of range ——, of lands subject to sale at the district land office at ———, and that I came into possession of said tract on the ——— day of ———. A. D. 18—, and have ever since remained in actual possession continuously; that I have located and opened a valuable mine of coal thereon, and have expended in labor and improvements on said mine the sum of ——— dollars, the labor and improvements being as follows: (here describe the nature and character of the improvements); and I do furthermore solemnly swear that I am well acquainted with the character of said described land, and with each and every legal subdivision thereof, having frequently passed over the same; that my knowledge of said land is such as to enable me to testify understandingly with regard thereto; that there is not, to my knowledge, within the limits thereof any vein or lode of quartz or other rock in place bearing gold, silver, or copper, and that there is not within the limits of said land, to my knowledge, any valuable deposit of gold, silver, or copper. So help me God.

——— ———.

29. When the township plat is not on file at date of claimant's first possession the declaratory statement must be filed within sixty days from the filing of such plat in your office.

30. One year from and after the expiration of the period allowed for filing the declaratory statement is given within which to make proof and payment; but you will allow no party to make final proof and payment except on notice to all others who appear on your records as claimants to the same tract.

31. A party who otherwise complies with the law may enter after the expiration of said year, provided no valid adverse right shall have intervened. He postpones his entry beyond said year at his own risk, and the Government can not thereafter protect him against another who complies with the law, and the value of his improvements can have no weight in his favor.

32. Each claimant at the time of actual purchase must make affidavit as follows:

I, ——— ———, claiming under the provisions of the Revised Statutes of the United States relating to the sale of coal lands of the United States, the right of purchase to the ——— quarter

of section ——, in township ——, of range ——, subject to sale at ———, do solemnly swear that I have never had the right of purchase under the aforesaid provisions of law either as an individual or as a member of an association, and that I have never held any other lands under its provisions; I further swear that I have expended in developing coal mines on said tract, in labor and improvements, the sum of ——— dollars, the nature of such improvements being as follows: ——— ——— ———; that I am now in the actual possession of said mines, and make the entry for my own use and benefit, and not directly or indirectly for the use and benefit of any other party; and I do furthermore swear that I am well acquainted with the character of said described land, and with each and every legal subdivision thereof, having frequently passed over the same; that my knowledge of said land is such as to enable me to testify understandingly with regard thereto; that the same is chiefly valuable for coal; that there is not, to my knowledge, within the limits thereof any vein or lode of quartz or other rock in place bearing gold, silver, or copper, and that there is not within the limits of said land, to my knowledge, any valuable deposit of gold, silver, or copper. So help me God.

——— ———.

33. The application, declaratory statement, and the affidavit required at the time of actual purchase, the forms of which are given above under paragraphs 23, 28, and 32, may be sworn to before any officer authorized by law to administer oaths, but the authority of such officer must be properly shown.

34. Any party duly qualified under the law, after swearing to his application or declaratory statement, may, by a sufficient power of attorney duly executed under the laws of the State or Territory in which such party may then be residing, empower an agent to file with the register of the proper land office the application, declaratory statement or affidavit required at the time of actual purchase, and also authorize him to make payment for and entry of the land in the name of such qualified party: and when such power of attorney shall have been filed in your office you will permit such agent to act thereunder as above indicated.

35. Where a claimant shows by affidavit that he is not personally acquainted with the character of the land, his duly authorized agent who possesses such knowledge may make the re-

quired affidavit as to its character; but whether this affidavit is made by principal or agent it must be corroborated by the affidavits of two disinterested and credible witnesses having knowledge of its character.

36. Nothing in these regulations shall be so construed as to prevent a party from proving his citizenship or age, or establishing the status of the lands sought to be entered, in accordance with ordinary rules of evidence; and any proof regularly introduced for that purpose that would be competent in a court or before a commissioner charged with the ascertainment of facts may be considered.

37. Assignments of the right to purchase will be recognized when properly executed. Proof and payment must be made, however, within the prescribed period, which dates from the first day of the possession of the assignor who initiated the claim.

38. The "Rules of Practice in cases before the United States district land offices, the General Land Office, and the Department of the Interior," approved December 20, 1880, (Revision approved January 27, 1899), will, as far as applicable, govern all cases and proceedings arising under the sections of the Revised Statutes above quoted providing for the sale of coal lands of the United States.

39. You will report at the close of each month as "sales of coal lands" all filings and entries in separate abstracts, commencing with number one and thereafter proceeding consecutively in the order of their reception. Where a series of numbers has already been commenced by sale of coal lands you will continue the same without change.

N.C.McFARLAND,
Commissioner.

To Registers and Receivers.

Department of the Interior, July 31, 1882.

Approved.

H. M. TELLER,
Secretary.

COAL CLAIMANTS' APPLICATIONS.

(From circular instructions issued Augusts 7, 1895 relative to deposits by individuals for the survey of public lands under

section 2401, Revised Statutes, as amended by the act of August 20, 1894.—21 L. D., 77.)

In addition to the rights of settlers, referred to in the foregoing portions of this circular, sections 2401, 2402, and 2403, United States Revised Statutes, as amended by the act of August 20, 1894, embrace provisions in favor of "persons and associations lawfully possessed of coal lands and otherwise qualified to make entry thereof."

The coal-land laws contained in sections 2347 to 2352, United Revised Statutes, provide methods by which persons properly qualified may become lawfully possessed of coal lands even before the survey of the lands, and be entitled to enter the same after survey. For particular information in regard thereto, reference is made to Department circular of July 31, 1882, entitled "Coal-Land Laws and Regulations Thereunder." Such parties, in cases where the tracts of which they are lawfully possessed are still unsurveyed, may, under said sections 2401, 2402, and 2403, as amended by act of August 20, 1894, apply to the surveyor-general for surveying district in which the lands are included, for a survey of the township or townships including the land according to the provisions of said sections. Such an application must be accompanied by the affidavit of the applicant or applicants substantially as prescribed for declaratory statements on page 7 of the said circular of July 31, 1882, corroborated by the testimony of two or more witnesses, in which the qualifications of the applicants, the character and location of the land, indicating the township or townships in which it is included as nearly as practicable, and other essential facts must be so set forth as to satisfy the surveyor-general that the case comes properly within the provisions of the law as above given. He will, thereupon, if he approves the application transmit the same to this office, with the required proofs and his report.

CIRCULAR.

Instructions concerning the acquisition of title to coal lands in Alaska, under the act of Congress approved June 6, 1900 (Public—No. 168), entitled "An Act to extend the coal-lands to the district of Alaska."

Department of the Interior,
General Land Office,
Washington, D. C., June 27, 1900

Registers and Receivers,
District of Alaska.

Gentlemen—Your attention is directed to the following act of Congress approved June 6, 1900, extending the coal-lands to the district of Alaska:

AN ACT to extend the coal-land laws to the district of Alaska.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That so much of the public-land laws of the United States are hereby extended to the district of Alaska as relate to coal lands, namely, sections twenty-three hundred and forty-seven to twenty-three hundred and fifty-two, inclusive of the Revised Statutes.

Under the coal-land law, sections 2347 to 2352, inclusive, of the Revised Statutes, and the regulations thereunder issued July 31, 1882, coal-land filings and entries must be by legal subdivisions as made by the regular United States survey.

Section 2401 of the Revised Statutes, as amended by act of August 20, 1894 is as follows:

Section 2401 (as amended by the act of August 20, 1894). When the settlers in any township not mineral or reserved by the Government, or persons and associations lawfully possessed of coal lands and otherwise qualified to make entry thereof, or when the owners or grantees of public lands of the United States, under any law thereof, desire a survey made of the same under the authority of the surveyor-general and shall file an application therefor in writing, and shall deposit in a proper United States depository to the credit of the United States a sum sufficient to pay for such survey, together with all expenditures incident thereto, without cost or claim for indemnity on the United States, it shall be lawful for the surveyor-general, under such instructions as may be given him by the Commissioner of the General Land Office, and in accordance with law, to survey such township or such public lands owned by said grantees of the Government, and make return therefor to the general and proper local land office: Provided, That no application shall be granted unless the township so proposed to be surveyed is within the range of the regular progress of the public surveys embraced by

existing standard lines or bases for township and subdivisional surveys.

Under said section 2401 as amended, persons and associations lawfully possessed of coal claims upon unsurveyed lands, may have such claims surveyed, provided the township so proposed to be surveyed is within the range of the regular progress of the public surveys embraced by existing standard lines or bases for township and subdivisional surveys.

Although the system of public-land surveys was extended to the district of Alaska by a provision contained in the act of Congress approved March 3, 1899 (30 Stat., 1098), no township or subdivisional surveys have been made nor have any standard lines or bases for township and subdivisional surveys been established within the district; therefore until the filing in your office of the official plat of survey of the township, no coal filing nor entry can be made.

BINGER HERMANN,
Commissioner.

Department of the Interior, June 27, 1900.
Approved.
E. A. HITCHCOCK,
Secretary.

Department of the Interior,
General Land Office,
Washington, D. C., January 5, 1904.

Registers and Receivers,
United States Land Offices.

Sirs: Paragraphs 30 and 31 of the Coal-Land Regulations (circular of July 31, 1882), were, on December 31, 1903, amended by the Secretary of the Interior, to read as follows:

30. One year from and after the expiration of the period allowed for filing a coal declaratory statement is given within which to make proof and payment; but you will allow no party to make final proof and payment except on notice to all others who appear on your records as claimants to the same tract. No notice will hereafter be given to parties whose coal filings have expired by limitation under the law.

31. A declarant who otherwise complies with the law may enter after the expiration of said year, provided no valid adverse

right shall have intervened but postpones his entry beyond said year at his own risk. Thereafter the land is subject to entry by any duly qualified applicant, without notice to the claimant under the expired declaratory statement; and the Government can not thereafter protect the latter against another who complies with the law or give the value of his improvements any weight in his favor.

Very respectfully,

W. A. RICHARDS,
Commissioner.